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Editorial

Traditionally all abstracts of contributions submitted to the 23rd General Assembly are included free of charge in the *Annales Geophysicae Supplement* once they were accepted by the appropriate convener(s) and once they were received in time, in the standard format and of sufficient quality for reproduction. Abstracts submitted for symposia included in two different parts of the Supplement issue are included (twice) in both parts, respectively.

Like in previous years, not all contributions included will actually be presented. Because of the lack of financial support, several young scientists as well as colleagues from the central and east-European countries will not be able to participate in the meeting, although the Society has continued its support schemes, such as the Young Scientists' Travel Award and the East European Support Award. In this way there are more abstracts included in the *Abstract Book* than contributions compiled in the *Programme Book*. Therefore, in order to simplify the ordering of abstracts within an event, we have adopted the alphabetical order with respect to the surname of the first author rather than the order of presentation in the *Abstract Book*.

With almost 5.800 contributions received, this Supplement of *Annales Geophysicae* has become an important open forum for fast distribution of results of geophysical research on a pan-European, international level, helping, at the same time, to promote the contact between all geophysicists in Europe. Please, support the fostering of cooperation and contact your colleagues also if not personally present this time. For this reason, the authors have also included a contact e-mail or fax number in their abstract for faster correspondence.

On behalf of the Society I am very pleased to welcome you to Nice on the occasion of the 23rd General Assembly of the European Geophysical Society. May your participation in this meeting be successful and scientifically rewarding.

A.K. Richter
Executive Secretary

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CONTENTS

Part I: Society Symposia, Solid Earth Geophysics & Geodesy

I.1 SOCIETY SYMPOSIA (EGS)

I.2. SOLID EARTH GEOPHYSICS (SE)

I.3 GEODESY (G)

Part III Space & Planetary Sciences

III.1 SOLAR TERRESTRIAL SCIENCES (ST)

SOLAR TERRESTRIAL SCIENCES (ST)

ST1 Review session on solar-terrestrial sciences

Convener: Fabian, P.
Co-Convener: Hapgood, M.A.

PROBLEMS IN THE PHYSICS OF SOLAR-TERRESTRIAL EFFECTS

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A general approach to this problem is formulated. It involves dividing all solar wind (SW) flows into two large classes: quasistationary SW streamers (a fast SW from coronal holes, and a slow wind flowing in streamer belts and chains), and sporadic streams (in the general case they include the sequences: shock wave, shock-heated plasma, and coronal mass ejection). Since sporadic streamers propagate over quasistationary streamers, these latter should be studied before sporadic streamers. By considering an example of fast SW streamers, it is shown that the physical picture of the SW streamers flowing out of the coronal hole and of the subsequent movement of the streamer to the Earth's orbit, based on analyzing current observational data, makes it possible to obtain semi-empirical relationships which describe reasonably well the quantitative correlation of coronal hole characteristics with parameters of related SW streamers at the Earth's orbit. Semi-empirical relationships are obtained, which relate coronal hole characteristics to instants of origin of terrestrial magnetospheric disturbances with $K_p > 5$ caused by fast SW streamers from these holes.

ESTIMATION OF THE AMOUNT OF ENERGY TRANSFERRED FROM SOLAR WIND TO THE EARTH MAGNETOSPHERE AND IONOSPHERE

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The solar wind MHD generator is the general energy source for all magnetosphere processes. The ionospheric Joule heating and ring current particle precipitations to atmosphere are the main energy losses. The field-aligned currents directly transport the energy and momentum of the solar wind plasma to the Earth's ionosphere and upper atmosphere. It is the first channel for energy transfer to the Earth's magnetosphere and ionosphere. The magnetospheric plasma sheet and tail lobe plasma convection generated by solar wind is the second energy source. The convection accompanies the plasma sheet and cold ionospheric polar wind ions acceleration. As result of this processes the ring current injection occurs during disturbed intervals. After recovery phase of the magnetic storm the energy is released in the form of ring current particle precipitations to atmosphere. The third energy transfer way includes the tail lobe magnetic field energy storage connected with the increasing of the tail current during southward IMF. After that the magnetospheric substorms occur. The previous magnetospheric state and solar wind conditions determine amount of energy which is transferred by each of mentioned above ways. Experimental evidences and model simulations are reviewed for each energy transfer process.

OUR NEW SUN

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The extremely successful Solar and Heliospheric Observatory (SOHO) mission is dominating solar physics research world wide. It is giving us a new view of our star, allowing us to probe the interior of the Sun, to map its atmosphere and to sample directly its particle emissions. In this talk a review of the observations made from the SOHO spacecraft will be given. Their impact on our understanding of the Sun will be discussed and, in particular, major new discoveries highlighted.

IONIZING RADIATION OF THE SUN AND SOLAR-TERRESTRIAL CONNECTIONS

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At present the monitoring of the solar EUV and soft X-ray radiation in the main ionizing spectral range of 0.8-120 nm are not carried out. The purpose of our project entitled "The creation of the permanent space patrol of the solar EUV and soft X-ray radiation" is to fill up this gap. The project is realized under International Science and Technology Center, Moscow. The response of the upper atmosphere and ionosphere on the solar flares have scarcely been studied experimentally. The main method of the vertical ionospheric sounding is not informative in this time because of there is the anomalous absorption of radiowaves. Therefore the verification of the theoretical models of the ionosphere is still difficult. In the present paper process of excitation of the Rydberg atomic and molecular states should be taken into account in the solar-terrestrial connections as a source of the information on the solar shortwave activity (associated with the solar flares, solar cycles and solar rotation). The Rydberg state radiation in the millimetric and centimeter waves penetrates downwards in the atmosphere and biosphere and can be registered on the Earth surface as the passive radio ionospheric sounding during solar flares and magnetic storms. This characteristic emission of the upper atmosphere can be probably considered as an "X-agent" in solar-atmosphere-biosphere connections proposed by Soviet heliobiologist A.L. Tchijevsky (1897-1964) sixty years ago.

GLOBAL RESPONSE OF OZONE TO COSMIC INFLUENCE

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Solar proton fluxes measured on base of monitoring by Russian polar satellites system "Meteor",galactic cosmic ray intensity (balloon measurements in Stratos phere at Murmansk, Moscow, Alma-Ata and Mirny), and total ozone content over globe (ground based and TOMS observations) were used to investigate a temporal and spatial structure of total ozone response to cosmic forcing. Statistical analysis has revealed a clear ozone response to strong SPE's in 1972,1989;1991 and 1997 (November). Negative response was revealed at high latitudes (of about 15 Dobson units when yearly averaged data were used), reduced practically to zero at 45 N and becomes positive at lower latitudes both for Southern and Northern Hemispheres.Decadal response of ozone to GCR which is in antiphase with solar cycle conteins a linear negative trend of about 1 DU/decade. Positive response ot total ozone at lower latitudes is discussed on base of photochemical modelling.

INVESTIGATION OF SOLAR-TERRESTRIAL RELATIONSHIP DURING GEOMAGNETOSPHERIC STORMS USING PATTERN RECOGNITION METHODS

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The investigation of complex system phenomena, such as the solar-terrestrial flares, the coronal mass ejections, and the geomagnetospheric storms (GMS), happening in the coupled solar-terrestrial system, requires to resort to the adequate investigation methodology and methods. It is suggested a new methodological approach system approach (SA) based on pattern recognition methods (PR). The main purpose of this methodology is investigation of complex phenomenon as integrity in which the set of studied processes of different modality is considered as tightly interconnected complex in space and in time. We try to outline very briefly one of the possible variants of a common approach of attack the solar- terrestrial relationship problem (as the starting point) during GMS. The essence of the approach is demonstrated on example of data analysis of the GMS as a key link of chain of the entire very complex inter-connected solar- terrestrial system. We belive that the application of suggested approach will be usefull to solve some problems of the cause-effect connection revealing when evaluating the action of the phenomena in the solar-terrestrial system impact on physical and technical environments.

SHORT- AND LONG-TERM OZONE LAYER VARIATIONS AND THEIR CORRELATIONS WITH SOLAR ACTIVITY

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Total ozone (TO) - solar activity correlations in the range of minutes - years have been established with the help of wavelet analysis and spectral analysis in glide time window as well. Power spectra of data sets of some daily solar parameters (sunspot numbers, 2.8 GHz indices values of solar mean magnetic field, Lyman & emission values etc.) have been compared with some geophysical parameters (TO, Earth's rotation velocity, ENSO index) spectra. It is shown: TO world network data sets exhibit 11-years periodicity only for some peiods and with a different coeffitients of correlation, the strongest Forbush decreases give the statistically significantly TO decreasings approximatly 1 Dobson unit. Amplitudes (1...15 D.u.) and periods (5...500 minutes) of TO oscillations in tropics show a good correlations with the indices of 2.8 GHz for the well known 27-days solar activity periodicity. This fact seems to confirm the dynamical nature of TO ozone oscillations and their connection with vertical wind variations caused by IGW. Possible mechanismes are discussed. The work was partly supported by the Russian Foundation for Fundamental Research, Grant No 96-05-66003.

THE STRUCTURE OF THE DAYSIDE MAGNETOPAUSE AND OF DAYSIDE AURORAL PRECIPITATIONS DUE TO PULSED MAGNETOPAUSE RECONNECTION

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The structure and variations of the dayside magnetopause and of the corresponding low-altitude precipitations are discussed in terms of the open magnetosphere model. In particular, a much-studied FTE event, seen by the AMPTE-UKS and -IRM satellites, is shown to be a partial crossing of an open low-latitude boundary layer (LLBL). Application of the stress-balance test reveals that the FTE is a convecting structure moving in a direction which is significantly different from the local magnetosheath flow. In addition, the method of Lockwood and Smith (1992) reveals that the field lines in the event core were opened in a pulse of enhanced reconnection rate. These results indicate that the event is caused by a thickening of the LLBL in response to a reconnection pulse, rather than being a consequence of a boundary indentation due to a magnetosheath pressure pulse. The ions injected across the magnetopause along the open field lines precipitate into the ionosphere where they form the precipitations classed as dayside boundary plasma sheet (BPS), LLBL, cusp, mantle and polar cap as the field lines evolve away from the open/closed separatrix and towards the tail lobe. Observations of these precipitations also show the predicted effects of pulsed reconnection.

THE NIGHSIDE MAGNETOSPHERIC TAIL

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A review of the nightside magnetospheric tail is presented according to recent observations. A strong emphasis is given to the coupling between the solar wind and the magnetosphere which leads to energy storage in the tail and to sudden energy dissipation starting at substorm onset. First the dynamics of the tail is examined from geosynchronous orbit to the far tail during substorm growth phase. It is shown how the tail magnetic field increase due to reconnection is linked to the overall increase of the tail current, to energetic particles deceleration at geosynchronous orbit and to plasmasheet thinning in the mid-tail. The location of the initiation region of substorms is deduced from multi-satellite studies of the tail field changes and from backward trajectories computations of bouncing ions. An attempt is made to link the mid tail dynamics with the far tail one using magnetic signatures of propagating cross-tail disruption, sudden plasma sheet thinning, travelling compression regions (TCR) and travelling plasmoid.

EL-NINO AS A LINK IN SOLAR -TERRESTRIAL CONNECTIONS: GEODYNAMICAL PROBLEMS

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El-Nino and Southen Oscillation (ENSO)- events correlate with correlation functions between equatorial components of Atmospheric and Geodetic Excitation Functions of the polar motion (cor(AGEF)) *(Nuzhdina, Kolaczek, 1997. Annales Geophisicae, Suppl.1, Vol.15, p.7.)*. Preliminary AGEF were filtered to obtain data series with anuual and semi-annual oscillations.
Maximum Entropy Spectral Analysis has been carried out for the cor(AGEF), ENSO, Wolf-numbers and geomagnetic activity index Ap. Main oscillations for *x*- and *y*- component of the cor(AGEF) have periods of about 20-28, 30-40, 50-60, 60-70 months. Analogous variatiuons take place in data series of ENSO, Wolf-numbers and Ap-index. Oscillations with periods 60-70 months and 20-30 months in geodynamical and ENSO data series are connected with the correspondent variations in solar activity and geomagnetic disturbanes. The first oscillation is a harmonic of the 11-year solar activity cycle; the last one is known Quasi-Biennial cycle.
The (cor(AGEF)) may be represented as an amplitude's modulated process, where semiannual and annual ocsillations are own variations of the AGEF and oscillations with periods of about 2-3, 5-6 years are the periods of amplitude modulation which takes place during ENSO events.

THE SOLAR RADIATION AND MODELS OF CONTROL PROCESSES OF WATER STORAGE DYNAMICS IN NORTH AFRICAN CONDITIONS

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It is very important to study the problems of the necessity of taking into account of solar radiation in models of control processes of water storage dynamics. Stimulating of optimisation these processes takes into account different meteorological factors and climatic parameters, and the role of the solar radiation in the production process and in system soil- plant-atmosphere is considered as the most important one. While simulating the dynamics of water storages we have developed the algorithm of calculating the operative control of irrigation time and rates. Model experiments realised with the help of the computer allowed to solve some theoretical problems of investigating and applying the theory of one way positive control to the solution of the concrete task of operative optimal control (Souf Eljil R., 1993, 1995).The information was obtained in complex investigations specific for the region under the study (Tunisia).Obtained temporary dependencies of solar radiation in conditions of North Africa reflect the phenomena of global scale. E.g. magnetic storm registered in conditions of avroral zone of south magnetic pole (Russia-Arkhangelskaya region) on the whole concedes with temporary structure FAR registrated in conditions of Tunisia. The synchronous reaction of cellular structures of different genotype on magnetique storm noted (Belesheva, 1995),it permits to wait and analogous influences on biological objects.

ST2 Open session on the middle atmosphere (co-sponsored by OA)

Convener: Dameris, M.
Co-Convener: Krüger, B.C.

BISPECTRAL ANALYSIS OF NON-LINEAR TIDAL/PLANETARY-WAVE COUPLING IN THE MESOSPHERE AND LOWER THERMOSPHERE

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Atmospheric tides in the mesosphere and lower thermosphere are known to exhibit considerable short-term fluctuations in amplitude. The mechanisms producing this variability are poorly understood, but are believed to include non-linear interactions between tides and planetary waves. Meteor-radar data collected over the UK between 1989 and 1994 are analysed in the light of current non-linear interaction theory, which suggests the production of secondary waves having frequencies that are the sum and difference of those of the primary waves (the tide and planetary wave) involved in the interaction. Quadratic phase coupling is also predicted between the primary and secondary waves. Bispectral analysis is a powerful technique for investigating the occurrence of such non-linear interactions and the suitability and limitations of this technique as a detector of quadratic phase coupling in geophysical data sets are discussed.

COMPARISON OF CRISTA I DATA WITH ER-2 MEASUREMENTS WITH THE HELP OF A TRAJECTORY MODEL

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CRISTA measurements of CFC11 and HNO_3 over Alaska at an altitude of about 20 km acquired during its first flight in November 1994 were compared with ER-2 observations in the same region over a time interval of eight hours at the beginning of the CRISTA mission. Though miss times and distances occassionally were low, at several locations non-negligible discrepancies occured between the mixing ratios found by both methods. As atmospherical dynamics were high in the investigated region, a two-dimensional isentropic trajectory model using analyzed winds has been applied to shift data from both observations to a fixed point of time for further comparison. The agreement between the mixing ratios from the two observations of both trace gases is shown to improve considerably following this analysis.

MASS EXCHANGE ACROSS THE SUBTROPICAL BARRIER IN A 3-D GLOBAL MODEL DURING A SIMULATED SUDDEN STRATOSPHERIC WARMING.

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The mass exchange from the tropics into midlatitudes across the subtropical barrier during a simulated midwinter stratospheric warming is investigated with a tracer experiment in a 3-d global gridpoint model.
The exchange process is driven by the activity of planetary waves and clearly dependent on height. The largest flux out of the tropics occurs between 15 and 20 km and is directed to the winter hemisphere. A smaller secondary maximum of flux of tropical air to midlatitudes is located near 30 km. Above this level, the flux from the tropics to midlatitudes decreases with height, reaching its minimum near the model stratopause.

SENSITIVITY STUDIES OF THE WINTER MIDDLE ATMOSPHERE WITH AN ADJOINT MECHANISTIC MODEL

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Four dimensional data assimilation has become operational in numerical weather prediction and is now beeing developed for GCM's too. Adjoint model formulations are therefore needed as efficient computational tools. They can also be used for sensitivity studies. We derived an adjoint model version from a global mechanistic model of the middle atmosphere (COMMA) to test physical parameterizations and predictability. To study Northern Hemisphere winter conditions we used three different data sets (SSU, UKMO, ECMWF) covering the time period from October 1991 until March 1997. For the lower stratosphere diabatic heating sources and planetary wave activity will be discussed. Above 10 hPa observations are less frequent and reliable. But accurate knowledge of the radiation and gravity wave fields is strongly recommended e.g. for climatologic calculations. To analyse main contributions to the observed mean stratospheric and mesospheric circulation we used the adjoint system for sensitivity studies taking into account both observations and model dynamics.

THE EVOLUTION OF THE STRATOSPHERE IN A 3-D GLOBAL GRIDPOINT MODEL AT THE PRESENCE OF STEADY STATE ENSO WARM AND ENSO COLD FORCING.

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A global 3-d mechanistic gridpoint model is used to investigate the response of the stratosphere to different climatological lower boundary forcing at 200 hPa. Three 1000 days model simulations with constant lower boundary forcing of the observered geopotential height fields at 200 hPa for January of ENSO cold, ENSO warm, and climatological mean will be compared in detail. Main emphasis is put on pronouncation of the stratospheric winter polar vortex and the intensity and the frequency of ouccuring stratospheric warmings.
The use of the geopotential heights at 200 hPa of the ENSO cold January leads to a better pronounced stratosheric polar vortex as at the presence of ENSO warm or climatological mean lower boundary forcing.

DUAL WAVELENGTH POLARIZATION LIDAR OBSERVATIONS AT TROPICAL LATITUDES DURING THE ALBATROSS CAMPAIGN 1996

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An analysis of high altitude cirrus cloud observations and stratospheric temperatures profiles derived from lidar observations during the ALBATROSS campaign (Atmospheric chemistry and lidar studies above the Atlantic ocean related to ozone and other trace gases in the tropo- and stratosphere) in October-November 1996 are presented. The measurements were performed aboard the German research vessel "POLARSTERN" between 35°N and 45°S. On the basis of dual wavelength polarization data the temperature dependence of the relation between the color ratios of the parallel and perpendicular backscatter coefficients are analyzed. We find an abrupt change at about 240 K which is interpreted as changes of particle shape and/or size distribution. At temperatures between 195 and 255 K a small fraction of the observations are consistent with the presence of small particles with dimensions of less than 0.1 μm. Altitude profiles of stratospheric temperature between 25 and 50 km are calculated by integration of the elastic backscatter signals at 355 and 532 nm. Deviations from the mean profiles are analyzed to study the wave activity in the tropical stratosphere.

EVIDENCE OF THE SECONDARY MERIDIONAL CIRCULATION ASSOCIATED WITH THE QUASI-BIENNIAL OSCILLATION OBSERVED IN THE DISTRIBUTIONS OF TRACE SPECIES

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Double peak structures observed in various chemical species in the tropical lower stratosphere imply sinking motion at the equator. The sinking motions are explained in connection with the secondary meridional circulation associated with the equatorial quasi-biennial oscillation. In this study, the meridional divergence points are located objectively in the tropical region at the boundary of rising and sinking motion from HALOE aerosol and HF. The locations of divergence are then compared with zonal wind and calculated meridional divergence. Divergence points are found with maximum easterly wind. In the time-altitude cross-sections of calculated divergence, divergence points are located in the divergence area. Contrary to the divergence points the convergence points are not easily located by the same objective method. The location of those convergence points found are not in agreement with the maximum westerly. The asymmetry between the divergence and convergence points seems to be the background rising motion due to residual circulation in the tropics.

STUDY OF WAVE PROCESSES, RAISED IN THE ATMOSPHERE BY THUNDERSTORM, WITH HELP OF MUON HODOSCOPE.

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New method of detection of internal gravity waves in atmosphere by means of ground level cosmic ray observations is developed. Muon hodoscope registers angular distribution of cosmic ray particles, which depends on air density up to 40 km height. The setup, constructed in Moscow (MEPHI), includes the microbarograph with sensitivity about 300 counts/mbar, and the muon hodoscope with area 9 sq.m and the angular resolution about 1-2 degrees. After calibration, this device was put into operation in 1997; it can continuosly register muon flux with statistical accuracy about 0.5% for 1 minute time intervals. The setup operated in the period of thunderstorm activity on May 6-15,1997. The characteristics of wave processes in atmosphere, at this time interval, have been obtained simultaneously with help of the microbarograph and muon hodoscope. It is found, that internal gravity waves, generated in periods of storm activity, are effectively registered by means of muon hodoscope with a level of reliability higher than 99.99 %. It is shown that time of life of a gravity wave in the period preceding the storm exceeds 4 hours, and distance of propagation of such wave can reach 200 km. At this time, the frequency resolution reached with muon hodoscope in peaks of power spectra density was 2-3 %, that is about in three times are better, than at microbarograph. Lengths of a waves in the period, preceding the storm, did not exceed 5 km, and 80 % of periods of gravity waves were in the range from 2 to 6 minutes.

IN-SITU MEASUREMENTS OF NEUTRAL ATMOSPHERE DYNAMICS IN THE POLAR MIDDLE ATMOSPHERE

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On October 12, 1997, a new rocket payload, RONALD, was launched from Andoya Rocket Range (69°17'N, 16°01'E), and a second one will be launched in January 1998. One of the instruments on board, a Rayleigh lidar, observes the total neutral density profile between 50 km and ~80 km on upleg, and from ~80 km to <40 km on downleg. We study the dynamics of the neutral atmosphere, waves and turbulence, with respect to transport mechanisms and energy dissipation rate. We also derive instantaneous temperature profiles from the density profiles. Ground-based lidar observations and falling sphere data allow comparison of this new method of measuring density fluctuations with established techniques. An ion probe and an electron probe on the same rocket potentially allow comparison with the well-known methods using ions as a tracer. The results of these observations will be interpreted in terms of neutral atmosphere dynamics.

STRATOSPHERIC SUDDEN WARMINGS IN THE BERLIN TSM GCM. PART 2: DIAGNOSIS USING THE TEM FORMULATION

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A ten year integration of the Berlin TSM GCM is used to demonstrate different evolutions of the Arctic polar vortex. The differences between the various wintertime sudden warmings in the Northern Hemisphere are described using the TEM (transformed Eulerian mean) circulation. The streamfunction for this meridional circulation shows a comprehensive picture of the time evolution. The relationship between the intensity of the streamfunction in mid latitudes and polar temperatures is investigated.
Because the streamfunction only describes the zonal-mean structure, the analysis is extended using the EPV (Ertel's potential vorticity), which describes the three-dimensional flow. Selected examples of different events (early wintertime warming, minor warming and major warming) will be discussed in this way.
The combined diagnostic framework incorporating the TEM Circulation and the EPV facilitates a clear description of the early winter conditions of the atmosphere and the evolution leading to the different types of warming events in the model.

LEE-WAVES IN THE STRATOSPHERE

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The occurrence of polar stratospheric clouds (PSC) under unfavorable environmental conditions has raised the question, whether large amplitude gravity waves can lead to parcel cooling rates suitable for PSC formation. We have investigated the problem under which circumstances lee waves can penetrate through the Tropopause and cause significant wave motion in the lower Stratosphere.
The investigations have been performed by linear and nonlinear numerical models for idealized and observed mean vertical profiles of wind and temperature upstream of mountain ridges. Some results obtained for the Norwegian mountains will be compared to observed lee-waves and related PSC formation.

ATMOSPHERIC TRACE GAS CORRELATIONS AS MEASURED BY CRISTA

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The CRISTA Instrument (CRyogenic Infrared Spectrometers and Telescopes for the Atmosphere) was flown on the Space-Shuttle missions STS 66 in November 1994 and STS 85 in August 1997. Global measurements of trace gases in the spectral range from 4 to 71 μm with high spatial resolution during free flying periods of 8 days in both flights were performed, and about 50000 height profiles were obtained in each flight. Correlations between the mixing ratios of several stratospheric constituents (e.g. N_2O, CH_4, HNO_3, O_3) for the first flight will be discussed and compared with model calculations.

ON THE VERTICAL WAVE-ENERGY PROPAGATION FROM TROPOSPHERE TO STRATOSPHERE IN DIFFERENT GEOGRAPHICAL REGIONS

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The vertical energy propagation connected with planetary waves controls up to a high extend the stratospheric circulation. The paper is concerned with the question of longitudinal and regional dependence of vertical wave-energy propagation.
For the 16 winter seasons of ECMWF reanalyses data covering 17 pressure levels the extended Eliassen-Palm-flux (EEPF) has been calculated for different characteristic timescales. The analyses show that the most dominant vertical synoptic wave-energy exchange with stratosphreric heights takes place over the North Atlantic region (NAR). In contrast to other geographical regions only in the NAR the synoptic wave-energy is able to penetrate up to stratospheric heights. Additional to the EEPF analyses this wave-energy window can be found in Principal Oscillation Patterns (POP) analyses, too. The so detected coherent wavepackets with oscillation periods between 5 and 10 days propagate only over the NAR up to the stratosphere. Besides this regional synoptic features it has been detected a more global travelling mode in the stratosphere with oscillation period of about 2 weeks. Both significant different POP structures may be interpreted in the framework of a linear theory.

MIDLATITUDINAL LOWER IONOSPHERE DISTURBANCES CAUSED BY NATURAL SOURSES

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There are presented experimental data on natural disturbances (powerful earthquakes, the solar terminator, strong thunderstorms, solar flares and magnetic storms) having effects on midlatitudinal ionospheric *D*-region parameters, characteristics of partially reflected (PR) signals and radio noise on f =2-4 MHz. There are investigated parameters of wave disturbances (type, periods, durations, and velocities) arising over these periods in the *D* region. Our investigations were carried out by the PR technique within a 1977-1997 period under different solar and geophysical conditions; the observation durations being minutes-days; ~30 to 200 samples covering each source of the disturbances.
The authors have been supported by STCU Grant 471.

GLOBAL MODEL OF CIRCULATION OF THE MIDDLE AND UPPER ATMOSPHERE

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The numerical three-dimensional model of the atmosphere circulation at altitudes from 20 to 300 km is suggested. This model is developed on a basis of the empiric models of the structural parameters of the strato-thermosphere. As the analysis shows, it is just such models which in the present time reproduce more precisely the observed systems of circulation. However, at the middle atmosphere heights, in distinction to the thermosphere, we have only the zonal-averaged distribution of the temperature, pressure and density. Thus, we have to calculate the atmosphere parameters variations conditioned by the tide oscillations and quasisteady planetary waves. We achieve this including the solution of the heat balance equation into the numerical model. The necessary non-adiabatic sources of the heating are found from the energy equation, in doing so, the circulation was beforehand calculation from the empiric models of the atmosphere which were supplemented at the stratosphere heights by the sources of the tide oscillations excitement. The variations of the atmospheric parameters connected with the planetary waves propagating from the troposphere were taken into account by setting the geopotential disturbances at the lower boundary.

IONOSPHERIC PARAMETER VARIATIONS IN THE LOWER *D* REGION DURING MAGNETIC STORM

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Using the partial reflection technique, it is found that the electron collision frequency increases more than 50% in the lower part of the *D* region (z <70 km) due to precipitating energetic particles during magnetic storms (MS). Measurements made during 3 MS in a 1984-1985 period near Kharkiv show that the precipitation occurs in a cource of ~10 days after the MS. On these events, intensive partial reflections are observed from heights of 55< z <70 km, and the electron number density increases several times. Calculations of flux intensities of precipitating energetic particles and ion-production rates are presented.
The authors have been supported by STCU Grant 471.

GLOBAL STRATOSPHERIC CIRCULATION ANALYSIS BY MEANS OF SPECTRAL DECOMPOSITION

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To give an objective characteristics of circulation patterns the spectral structure of stratospheric fields (temperature and geopotential) is analyzed in terms of the spherical harmonics with the aim to compare the long-term behaviour and connections to some extra-terrestric influence and circulations patterns. The daily meteo data from Free University Berlin cover more or less the period 1976–96 and are available for stratospheric levels 50, 30 and 10 hPa. The analysis of annual course of spherical harmonics is introduced as well as the comparison of the principal wave components changes with respect to the changes of different sets of solar, geomagnetic and global circulation indices. The interannual variability with special emphasis to the QBO and ENSO is also studied. Quite high correlation is found for some wave numbers.

WATER IN THE ATMOSPHERE AND MESOSPHERE

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Water is the only substance that occurs in all three phases, gaseous, fluid and solid – monomer and polymer (cluster) – in the Earth's atmosphere. The spatial and temporal distribution of H_2O is not only very important for the climate, weather, biosphere and atmospheric chemistry – homogeneous and heterogeneous – but also for the propagation of electromagnetic waves through the atmosphere. The climate of the Earth has never been static. It is very much different now from what it was during cretaceous when dinosaurs dominated the life of Earth. Since climate is the sum of all weather over longer periods of time we must ask ourselves how much climate, like weather, is predictabel. Water vapor in the atmosphere can be measured using microwave techniques, such as those used in experiments made by the MPAE. The major questions are now:

1. How much extraterrestrial water exists in the atmosphere?
2. How variable is the total hydrogen budget over a longer time period?
3. Is the polar mesosphere an early warning system for global change?
4. Can the strength of El Nino better estimated using microwave measurements in the equatorial tropopause?

THE QUASI 16-DAY WAVE IN THE SUMMER MIDLATITUDE MESOPAUSE REGION AND ITS DEPENDENCE ON THE EQUATORIAL QUASI-BIENNIAL OSCILLATION

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From 16 years of daily estimates of the summer midlatitude mesopause region zonal prevailing wind measured at the Collm Observatory of the University of Leipzig, Germany, long-term variations in the period range of planetary waves (10-20 days) are detected. Although the direct propagation of these waves from the troposphere into the mesosphere is not possible because of the wave filtering through to the summer stratospheric and mesospheric easterlies, in some years oscillations are found that can be connected with planetary waves, supporting the theory of the propagation of these waves from the equatorial region to the midlatitude and polar upper mesosphere along the zero wind line. This wave activity is dependent on the equatorial quasi-biennial oscillation (QBO), so that in general during the east phase of the QBO the planetary wave activity is small, while during the QBO west phase it can be larger. The influence of the QBO on the planetary wave activity is modulated by the 11-year solar cycle, so that the strongest QBO signal is found during solar maximum.

MEAN DIURNAL VARIATIONS OF PMSE AND WINDS AS MEASURED WITH THE ALOMAR-SOUSY RADAR DURING THE SUMMER MONTHS FROM 1994 TO 1997

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VHF radar observations of the structure and dynamics of Polar Mesospheric Summer Echoes (PMSE) have been carried out at Andenes (69.3° N, 16.0° E) using the ALOMAR SOUSY radar operated at 53.5 MHz for four summer seasons from 1994 to 1997. The radar measures 3D winds and reflectivity profiles mainly with a range resolution of 300 m and a time resolution of about 30 sec. The total number of about 3500 hours observation time allows detailed studies of the seasonal variations of PMSE which are closely connected to the cold temperatures at the mesopause region at high latitudes during the summer months.
Based on these data hourly means of the reflectivity and winds have been determined in order to describe the diurnal variation of the occurrence of the PMSE which is characterized by a minimum around 19 - 21 LT and a maximum at about 14 LT. This behaviour is discussed for the whole data set and for partial periods of the PMSE season in relation to the mean winds and tides derived from the ALOMAR SOUSY radar using the Doppler beam swinging technique.

MEASUREMENTS OF SUMMER MESOPAUSE REGION ZONAL WINDS OVER CENTRAL AND EASTERN EUROPE

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Measurements of the zonal prevailing wind in the mesopause region, i.e. between 80 and 100 km height have been carried out during three campaigns in August 1994, 1995 and 1996 by the Kharkov State Technical University of Radioelectronics, Ukraine, with the aid of a meteor radar at 50°N, 37°E. The results are compared with the total reflection low-frequency mesopause radio wind measurements at 52°N, 15°E that are carried at the Collm Observatory of the University of Leipzig, Germany. While in 1994 and 1995 the zonal prevailing winds at Kharkov and Collm are similar, in 1996 at Collm lower prevailing winds are measured. The amplitude of the semidiurnal tide at Kharkov is larger than at Collm, while generally the phase is in good agreement at both sites. The amplitude of the quasi 2-day wave is low during each of the periods. Only in 1995 a moderate event has been identified. From phase comparison a zonal wavenumber of 2.6 is inferred.

CLIMATOLOGY AND TIDAL INTERACTIONS OF SHORT-PERIOD GRAVITY WAVES AT METEOR HEIGHTS

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A twin-beam meteor radar located in the UK has been used to measure horizontal velocities at meteor heights between 1989 and 1994. Although the radar cannot easily identify individual gravity waves within the broad meteor collecting volumes, the variance of the velocities nevertheless provides a statistical measure of the activity of the gravity-wave field. Using this measure of wave activity, a seasonal cycle for gravity waves with periods < 1 hour is revealed which shows solsticial maxima and equinoctial minima. There is considerable year to year variability. A time-series analysis of the data indicates that the wave activity is strongly modulated by interaction with both the 12 and 24 hour tides. The seasonal behaviour of this modulation is investigated and defined.

LABORATORY AND MODELING STUDIES OF $CO_2 + O(^1D)$ ISOTOPIC EXCHANGE

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Carbon dioxide in the middle atmosphere is mass independently enriched in oxygen isotopes ($\delta^{17}O \neq 0.5\delta^{18}O$) relative to tropospheric values, with the enrichments typically increasing with altitude. That is, with increasing altitude, the $^{17}O/^{16}O$ ratio shows an additional enhancement over what is normally expected on the basis of the $^{18}O/^{16}O$ increase. As tropospheric CO_2 has a mass dependent isotopic composition that is relatively constant, isotopic measurements of atmospheric CO_2, combined with a quantitative understanding of the enrichment mechanism, will yield valuable information regarding important atmospheric processes. It is known that the mass independent enrichment in stratospheric CO_2 occurs when CO_2 quenches an $O(^1D)$ formed during the photolysis of O_3, but the details of this process remain uncertain. We have performed a series of laboratory and numerical experiments designed to study the time evolution and final equilibrium values of the $CO_2+O(^1D)$ reaction. Developing a quantitative understanding of the middle atmospheric CO_2 enrichment process is important because the mass independent signature can provide information regarding atmospheric dynamics, the isotopic composition of atmospheric O_3, and $O(^1D)$ concentrations in the middle atmosphere.

TRANSPORT ACROSS THE SUBTROPICAL BARRIER AS OBSERVED BY THE CRISTA EXPERIMENT AND THE KASIMA/CTM

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On November 3, 1994 the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere (CRISTA) was launched aboard the Space Shuttle Atlantis into a 300 km, 57° inclination orbit and measured about 50,000 height profiles of limb radiance spectra. On November 6 1994 CRISTA analyses of N_2O and HNO_3 show three narrow tounges of mixing ratios pointing from the tropics poleward and eastward. Idealized transport experiments with the KArlsruhe SImulation model of the Middle Atmosphere (KASIMA) strongly support the hypotheses that these tounges are due to an advective transport process on a timescale of several days. The analyses is based on a subjective comparison as well as on objective statistical correllations between the CRISTA and the KASIMA analyses.

SIMULATIONS OF MIDDLE ATMOSPHERE WINDS AND COMPARISON WITH LONG-TERM MESOPAUSE WIND MEASUREMENTS AT COLLM OBSERVATORY (52° N 15° E)

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Simulations of wind field dynamics in the upper mesosphere and lower thermosphere (MLT) region are performed with the COlogne Model of the Middle Atmosphere (COMMA) at the Leipzig Institute for Meteorologie (LIM). Numerical simulations in a nonlinear model are able to give an insight into energy transfer and coupling processes in the MLT region. Well analyzed wind measurements with high reliability of the dynamical parameters are necessary for an accurate interpretation of model results and to bring effects of tides and planetary waves into focus, that are of actual interest. In this connection the results from the Comma model of the middle atmosphere are compared with the long-term midlatitude wind measurements from the Collm observatory.

TRANSIENT PLANETARY WAVES STRUCTURE IN THE MIDDLE ATMOSPHERE DURING 1991-1992 : UARS DATA ANALYSIS AND NUMERICAL MODEL RUNS

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Temperature UARS data (ISAMS instrument) from 100 mb up to mesospheric levels jointly with UKMO assimilated data and lidar temperature data were used to study character periods and wave numbers of transient planeta ry waves in the middle atmosphere with special attention to waves intensity at higher levels. Due to rather poor temperature mesurements by ISAMS instrument (in spite of its possibility for measurements in mesosphere) MEM spec tral teknique was used. The results of data analysis has revealed different character periods of oscillations like 2-3, 5-7 and 9-15 days which exist also in the mesosphere Similar periods were found also in D-region radio wave absorbtion. It is interesting to pay attention to the wave with the period near 2-3 days which has zonal wave number m=3. Spectral density of temperature for m=1,2,3 from 100 to 0.01 mb was calculated. The transient planetary waves existance at high levels of the middle atmosphere permits to suppouse of its penetration from troposphere. Numerical model runs support this idea. The waves which were obtained as a result of data analysis are in a good correspondence with "resonant" or normal waves which were genarated in model.

STRATOSPHERIC SUDDEN WARMINGS IN THE BERLIN TSM GCM, PART I: SENSITIVITY TO RADIATIVE HEATING RATES AND RESOLUTION

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Erlebach et al. (1996) reported on the successful simulation of sudden stratospheric warmings in a 28-year integration of the Berlin troposphere-stratosphere-mesosphere general circulation model (GCM). The model was able to capture many of the observed characteristics of the warmings. e.g. major and minor events, their frequency and coupling to the troposphere. Some details of the evolution of the warmings however could not be reproduced properly by the model: e.g. the erosion of the polar vortex during major warming events and the restoration of the wintertime circulation. It was argued that the low horizontal resolution or a too weak radiative forcing might be responsible for that. Here, the discussion of these questions is continued using the results from a 10-year integration of a new model version. Major differences include an improvement of the IR-radiation parametrization in the stratosphere and of the ozone climatology. Different types of sudden stratospheric warmings developed during the 10 northern hemisphere model winters. enabling a systematic analysis of the new model results with respect to deficiencies identified in the previous model version. The influence of the radiation and the model resolution on the simulated climatology and interannual variability will be discussed in some detail.

THE "16-DAY" EASTWARD-TRAVELLING WAVENUMBER 2 IN THE STRATOSPHERE: A COMPARISON BETWEEN THE HEMISPHERES

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A wave calender of the Northern Hemisphere (NH) stratosphere has revealed an interesting feature: a "quasi-16-day" eastward travelling planetary wavenumber 2. which occurs during Winter at high latitudes. This wave is a well-known. regularly occurring phenomenon in the Southern Hemisphere (SH). where its interaction with the quasi-stationary forced wavenumber 1 is related to a quasi-periodic amplifications of that wave; this can lead to minor midwinter warmings. as occurred in August-September 1988. This warming mechanism is quite different from that of major warming events in the NH.
In this study, clear evidence of an eastward travelling wavenumber 2 event in the 1982/83 NH Winter is presented. It is related to several minor warmings. This case study will show that the 1982/83 NH and 1988 SH minor warmings have develop similarly. Nevertheless. the wavenumber 1/wavenumber 2 interactions in the two cases are different.

FIRST IN SITU TEMPERATURE MEASUREMENTS IN THE SUMMER MESOSPHERE AT ANTARCTIC LATITUDES

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In the austral summer 1997/98 a series of meteorological rockets will be launched from the British Antarctic Station Rothera (68°S,68°W). The falling sphere technique will be used to determine mass density profiles from approximately 95 km to 30 km. Temperature profiles are deduced from these densities assuming hydrostatic equilibrium. Some preliminary results will be shown which represent the first in situ measurements in the upper atmosphere at southern latitudes. In order to study a potential north/south asymmetry of the thermal structure of the high latitude summer mesosphere our results will be compared with falling sphere measurements performed from the Andøya Rocket Range (69°N,16°E) during the summer of 1997.

STRATOSPHERIC LOW FREQUENCY VARIABILITY IN MID AND HIGH LATITUDES: "TRIPLE PEAK SPECTRA" OR "BIENNIAL OSCILLATION"?

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In a series of papers, Tung and Yang (1994a,b) and Yang and Tung (1994, 1995) proposed that the QBO related interannual variability of total ozone in mid and high latitudes is characterized by a "triple peak" spectrum with peak amplitudes at periods of 8.5, 20 and 30 months. According to the authors, this spectral signature is the dynamical fingerprint of the tropical Quasi-Biennial Oscillation in mid and high latitudes.
However, Salby (1997) and Baldwin and Dunkerton (1997) demonstrated that the low frequency variability in certain dynamical stratospheric quantities at high latitudes is dominated by variations with periods of 24 months. The origin of this "Biennial Oscillation" is left unexplained.
By performing an EOF analysis on monthly mean fields of the circulation in the northern hemisphere stratosphere, spectral features of the low frequency variability in mid and high latitudes are examined. It is shown that, depending on the time period and pressure level in question, both triple peak spectra and purely biennial modes can be found. Extending the original argument of Tung and Yang by taking the "Ten-to-Twelve-Year Oscillation" (Labitzke, 1987, Labitzke and van Loon, 1988) into account, it is discussed how the observed spectral properties of stratospheric low frequency variability can be understood.

MODELING OF THE TIME VARIATION OF THE ATMOSPHERIC TEMPERATURE, PRESSURE, AND CIRCULATION ASSOCIATED WITH THE SOLAR PROTON EVENTS

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The time variation of the air temperature, pressure, and circulation in the middle and high latitute troposphere and low stratosphere associated with intense burst of solar cosmic ray flux is modelled. The model is based on supposition that enhances flux of energetic particles causes the apperance in the high latitude stratosphere of an optically active layer. This layer is supposed to reflect about to 10% of the incident short-wave solar radiation. The variation of the radiative balance may produce a changes of the temperature height profile in the high latitude atmosphere, meridional pressure profile, which in turn might cause the change of the zonal circulation. The model data are shown to be in a good agreament with experimental ones.

VARIANCES AND SPECTRA OF GRAVITY-WAVE VERTICAL VELOCITIES AT MESOPAUSE HEIGHTS

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The EISCAT VHF radar has been used to record vertical winds at mesopause heights on 31 days between June 1990 and January 1993. The data reveal a motion field dominated by quasi-monochromatic gravity waves with periods ~ 30-40 minutes, amplitudes of up to ~ 2.5 ms-1 and large vertical wavelength. In some instances waves appear to be ducted. Vertical profiles of the vertical-velocity variance display a variety of forms and profiles evaluated for consecutive days often show a persistent general shape. The mean variance suggests a semi-annual seasonal cycle with equinoctial minima and solsticial maxima. The mean vertical-wavenumber spectrum evaluated at heights up to 86 km has a slope (spectral index) consistent with observations at lower heights but disagreeing with the predictions of a number of saturation theories advanced to explain gravity-wave spectra. The spectral slopes are steeper (more negative) in summer than in winter and appear to be generally steeper on days with lower mean vertical-velocity variance.

TROPICAL WAVES IN THE BERLIN TSM GCM: AN INTERCOMPARISON BETWEEN TWO DIFFERENT VERTICAL RESOLUTIONS

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Most middle atmosphere (MA) GCMs are not able to capture the time dependency of the zonal mean flow near the equator adequately. Recent studies imply that higher vertical resolutions of the models lead to a better representation of tropical dynamics, due to the fact that smaller vertical wavelengths can be resolved. To study the impact of the vertical resolution on the tropics, a new version of the Berlin TSM GCM was used: The radiation code was replaced by a state-of-the-art scheme based on the Morcrette parameterisation which was developed by Zhong. The model can be run with two different vertical resolutions. The 34-level version has a vertical spacing of 3.5 km in the MA while the 70-level version reduces the spacing in the MA to approximately 1 km.
The tropical wave spectra simulated by the two versions are compared. The changes in the mean flow evolving at the equator will be analysed. The relationship between the wave spectrum and the mean flow will be discussed.

SECULAR VARIATION OF THE 11-YEAR CYCLE OF THE TEMPERATURE, PRESSURE, AND PRECIPITATION IN THE USA FOR PERIOD 1700-1988 ASSOCIATED WITH THE CHANGES OF THE SOLAR ACTIVITY

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Analysis of variation of the temperature, precipitation and pressure in USA from 1700 to the present allows us to assume the existence of a noticeable variation of these parametres in the North American region in the course of the 11-year solar activity cycle. The most interesting results are the spatial and temporal changes of the character of the cyclic variation of the temperature, pressure, and precipitation for all seasons. The physical mechanism responsible for this change seems to be related with the variations of the distribution of the atmospheric pressure and, as consequence, of the circulation in the course of secular cycle of the solar activity.

A METEOROLOGICAL REVIEW OF THE STRATOSPHERIC WINTER 1997/98

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The stratosphere displays a wide range of interannual variability of the evolution of the polar vortex and the associated temperatures in winter and spring. The development of the stratospheric circulation at polar and middle latitudes during the northern hemispheric winter 1997/98 is shown by several relevant parameters such as the temperature, the geostrophic wind, the geopotential vorticity, and the planetary wave activity.
The temperature history of the winter 1997/98 will be compared to the long record of data from the Stratospheric Research Group Berlin to evaluate the possibility of a continuing cooling trend.

PLANETARY SCALE WAVES OBSERVED IN THE LOWER IONOSPHERE DURING CRISTA I CAMPAIGN

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By means of the MEM spectrum analysis of absorption measurements over Europe and fmin data in Europe and Asia, the main planetary wave type fluctuations (T = 3-25 days) in the upper middle atmosphere CRISTA I campaign (October-November 1994) are studied. Three dominant period bands are found: 3-5, 6-8 and 15-23 (mainly 16-18) days. Similar fluctuations are observed in the prevailing neutral wind near 95 km over central Europe. A very well developed ~10-day fluctuations are found only in fmin and zonal prevailing wind at Irkutsk. For 4-day fluctuations, the westward propagation is found with wavenumber K = 4, while for 7-8 and 16-18 days ones, the eastward propagation with wavenumber K = 3 and K = 1, respectively. This surprising result could not be checked by wind data due to their scarcity. The strength of planetary wave activity at middle latitudes seems to be fairly consistent with the undisturbed (climatological) state of the atmosphere at 80-100 km.

THE SOUTHERN HEMISPHERE WINTER OF 1997

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The meteorology of the 1997 Winter in the Southern Hemisphere is being investigated in some detail using the GEOS-1 data assimilation system developed at NASA GSFC. In this study, particular attention will be devoted to the breakdown of the polar vortex in the early part of November. A range of diagnostics will be used to show the roles of eddy forcing from the troposphere and the radiative effects due to the increasing solar insolation in the polar region. The mixing of air parcels from the polar vortex over the southern hemisphere will be discussed. Short forecasts using the numerical model will be used to examine the predictability of the vortex breakdown, thereby isolating features which are critical to the evolution of the stratospheric flow. Comparisons with other analyses and with total ozone fields will be made.

INITIAL CONDITIONS AND SPIN-UP : COMPARING STRATEGIES FOR USE IN CTMS

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The study of the impact of initial or sustained imbalances in three-dimensional chemical transport models has yet received little attention. For most simulations, assumption is made that the initial perturbed trace constituents fields equilibrate during the first weeks, which are then discarded. In addition, two-dimensional reduced models are often used to generate pre-equilibrated fields at a relatively low computational cost -still, the derivation of three-dimensional fields from these estimates necessarily induces some perturbation. The increase in the realism of CTMs, with the explicit consideration of surface emissions or alternatively of prescribed troposphere-stratosphere exchanges, brings a new incentive to consider strategies to determine the extent of the coupled non-linear effects of dynamics and chemistry, and prospectively to reduce them. We have set up an experiment intending to compare several techniques of initialization starting from two-dimensional fields (zonal average, total column) or from a collection of sonde profiles. We use the REPROBUS CTM of the stratosphere, with three-dimensional equilibrated fields to generate the inputs, in order to isolate the effects of the concurrent initialization procedures. We analyse the various time-scales involved and discuss on the limitations imposed by the present scarcity of the chemical measurements of the middle atmosphere.

AN EXAMINATION OF VERY COLD PERIODS IN THE LOWER AND MIDDLE STRATOSPHERE OF THE NORTHERN HEMISPHERIC WINTER

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For different reasons a climatology of very cold periods in the lower stratosphere during winter is needed: An examination of low temperatures in the northern hemisphere is a good indicator for climate change and changes in the atmospheric circulation. Some studies also suggest, that the occurrence of low temperatures is connected to the ozone depletion.
Two main data sets are used for the investigation: daily maps of geopotential height and temperature fields at three stratospheric levels (50, 30 and 10 hPa) which have been analysed at the Freie Universität Berlin since 1963 and several data sets of radiosondes. Using the analyses we carried out the duration and time of occurrence of very cold periods at the levels for every winter season and we found out the locations of the centres of the cold areas during these periods. Moreover we examined the existence of typical circulation patterns when cold periods occurred. The temperature fields are also correlated with the NAO index. Using different reports of radiosonde ascents we investigated the behaviour of extremely low temperatures.

EMERGING NEW ATMOSPHERIC CHEMISTRY OF NITROUS OXIDE AND ITS IMPLICATIONS

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Theoretical considerations (Prasad, JGR, **99**, 5295, 1994 & **102**, 21,527, 1997) predict and laboratory experiments (Zipf & Prasad, EOS, Trans. Am. Geophys. Union, Suppl., **78**, S82, 1996 and a paper in preparation) confirm substantial production of N_2O in both the troposphere and the stratosphere from excited nascent O_3 and/or "embryonic" O_3. This production may easily exceed 30% of the "classical" sinks. The observed stratospheric N_2O mixing ratios will not be perturbed by the new source because of: (1) the inevitable loss reactions $N_2O + O_2(b) - N_2 + O_3$ and the $N_2O \bullet O_2 + hv - N_2 + O_3$ implied by our observed new N_2O formation mechanism, and (2) the observed enhancement in the photolysis of N_2O resulting from the $N_2..O..N_2$ complex formation (to be published).These new sources and sinks of N_2O have many important implications. If we accept the current WMO position of nearly balanced N_2O sources- sinks budget, then the new tropospheric source implies the existence of hitherto unrecognized biogenic sinks. The emerging new N_2O chemistry also implies caution in the use of N_2O as a tracer of dynamical motions. These and other important implications will be discussed.

ANALYSE OF THE WAVES DURING FRONTS PASSAGES

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Two lee wave experiments were realised in winter 1996-1997 and 1997-1998 in North Scandinavia. Lidars, Radars and ALIS system cameras were located on the two sides of Scandinavia mountains. We analyse here the data from ESRAD MST radar located at ESRANGE [68. °N, 21. °E] in the lee of Scandinavia mountains. This radar operates at 52 MHz, it has 72kW peak power (12 modules of 6 kW each) and a square antenna array consisting of 140-5 element yagis. The yagis can be grouped in different ways and the signal channelled to 6 different receivers.Winds, velocity perturbations associated with waves, and characteristics of turbulence from 1 km up to 10-15km altitude can be studied with a resolution of 300 m. The analysis of the first experiment shows that the waves are often generated during frontal passages which are frequent in this area during winter. We will try this year, by a comparaison of the data during two years to analyse the evolution of the frontal passages and the corresponding winds. Because, the waves are directly correlated to the wind (intensity and direction), we will try to understand better the formation of the waves and their evolution. In addition, we will try to see if we can anticipate the formation of the PSCs with the forecast data from the bulletin weather maps and the ECMWF data.

Temporal evolution of stratospheric chlorine monoxide over alpine stations

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The present analysis deals with the chlorine monoxide fields as measured by a ground-based microwave radiometer located at the Plateau de Bure (45°N, France), as measured by the Microwave Limb Sounder (MLS) instrument aboard the Upper Atmosphere Research Satellite (UARS) over the station and as modelled by the three-dimensional SLIMCAT model over the station. Temporal coverage ranges from from fall 1991 up to summer 1997 over a vertical extent from ~50 hPa to ~1 hPa. Since there are very few chlorine activation events in the lower stratosphere over Bure, the analysis will mainly focus on mid-stratospheric ClO behaviour over a short-term period (diurnal variation) and over a mid-term period (seasonal variation) in order to assess any positive trend in the stratospheric chlorine loading over the 5-year period.

ON THE EXCITATION OF EQUATORIAL WAVES BY DEEP CONVECTION IN THE NCAR COMMUNITY CLIMATE MODEL

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The vertical propagation of equatorial waves forced in the troposphere plays an important role in the dynamics of the middle atmosphere. In order to study the excitation of equatorial waves in the NCAR Community Climate Model (CCM3), the heating field due to deep convection is analyzed. Projection of the model heating field onto Hough modes gives information about equatorial waves (Rossby, Kelvin and gravity modes) excited over the range of zonal wavenumbers 1-64 and frequencies 0-4 cpd. The Hough spectrum of the geopotential contains all the information necessary to evaluate the upward component of EP flux due to waves excited by deep convection in the CCM3. The results of this analysis are compared to spectra obtained from a similar analysis of the brightness temperature of deep convective clouds (a proxy for convective heating fluctuations in the atmosphere). The comparison indicates that excitation of high frequency waves is underestimated in the CCM3 compared to the observations.

A COMPREHENSIVE THREE-DIMENSIONAL ASSIMILATION SYSTEM FOR OZONE AND OTHER TRACE CONSTITUENTS

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A three-dimensional ozone assimilation system has been developed at the Data Assimilation Office at NASA's Goddard Space Flight Center. The system is driven by analysis winds, and it uses total ozone observations from TOMS and middle/upper stratospheric ozone profiles from SBUV2 for generating global three-dimensional ozone fields at 6-hourly intervals in near-real time. The primary user-group are satellite instrument teams who need reliable background estimates of ozone profiles for their retrieval algorithms. However, access to dynamically consistent ozone fields is expected to be useful also for the investigation of a number of middle atmosphere research topics, such as stratospheric/tropospheric exchange, atmospheric chemistry, and climate impact of changes in the ozone layer. The system is being expanded to accommodate other minor atmospheric constituents along with ozone. We will give an overview of the system and we will show results from the validation of the three-dimensional structure of the assimilated ozone fields.

RADAR MEASUREMENTS OF FINE STRUCTURES OBSERVED IN THE LOWER ATMOSPHERE

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Measurements using the SOUSY VHF Radar in the Harz mountains in Germany have been carried out in the summer of 1996. For studying the structure and dynamics with high temporal and spatial resolution, the beam was pointing continously in the vertical direction and the range resolution used was 75 m. Fine structures in the echo intensity are observed during a frontal passage and are related to humidity fluctuations. Integrating the high resolution velocity data with time allows us to estimate vertical displacements that can be used to indicate vertical transport. The velocities are analysed harmonically and interpreted as waves with periods of about 6 h and amplitudes of a few cm/s. Observations during a thunderstorm reveal strong convective cells with lifetimes of about 10 to 20 minutes, associated up and down drafts and a series of persistant stable layers in the troposphere ahead of the thunderstorm.

THE PECULIARITIES OF THE LOWEST OSCILLATION'S MODE IN THE ATMOSPHERE WITH REALISTIC TEMPERATURE DISTRIBUTION

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A model analysis of the properties of the lowest oscillation's mode is considered. Any vertical profile of the atmospheric temperature can be well approximated as a ratio of two polynomials of the same power. For considered altitude temperature profile, an exact solution determined the properties of the lowest mode of oscillations in the non-isothermal atmosphere is found. The frequency of the lowest mode is also determined. The influences of the nonlinear waves absorption at this frequency is investigated so far as the oscillation's amplitude has the fast altitude growth. Different upper boundary conditions are considered.

RESPONSE OF THE STRATOSPHERE TO INTERANNUAL VARIABILITY IN THE TROPOSPHERE.

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Tropospheric variability such as the Southern Oscillation provides interannual variability in quasi-steady planetary waves near the tropopause. A mechanistic, primitive equation model was integrated under perpetual January conditions with different levels of steady wave forcing at 100hPa to investigate the effect of this variability on the stratosphere. With idealized forcing, differences in the amplitude of the waves at tropopause level lead to qualitatively different states in the stratosphere. These results are viewed in the light of similar experiments with simpler, quasi-geostrophic models. When the idealized forcing is replaced with observed steady planetary waves, similar states are found. These cases will be compared with ensembles of integrations where the perpetual January conditions are replaced by a seasonal cycle and transient wave forcing is included.

SIMULTANEOUS MEASUREMENTS OF NOCTILUCENT CLOUDS AND POLAR MESOSPHERE SUMMER ECHOES ABOVE NORTHERN SCANDINAVIA IN AUGUST 1997

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Simultaneous and common volume observations of noctilucent clouds (NLC) and polar mesosphere summer echoes (PMSE) were performed in August 1997 above Esrange (67.9N, 21.1E) near Kiruna, Sweden. On two occasions. NLC layers were observed by lidar with mean backscatter ratios of 12 and 25 at 532 nm and mean altitudes of 84.3 and 83.4 km, respectively. During both NLC events, several PMSE layers were observed by the MST radar on Esrange with S/N up to 5 dB in an altitude range between 82.0 and 88.9 km. The first of these NLC events has also been recorded by a camera placed about 380 km south of Esrange. During the jointly observed NLC/PMSE events NLC signals occurred with and without PMSE present in the same scattering volumes at same times, as well as higher altitude PMSE layers ondulating correlated with the lower altitude NLC-layer. One of the PMSE layers appears to convert to a NLC layer during the observations.

MIDDLE ATMOSPHERE WINDS AT OBSERVATOIRE DE HAUTE-PROVENCE (44°N) BY DOPPLER RAYLEIGH LIDAR: SEASONAL AND PLANETARY SCALE VARIABILITY.

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The regular operation of a Doppler wind lidar since August 1995 at Observatoire de Haute Provence (44°N) has offered the first data base of continuous remote measurements of horizontal winds in the middle atmosphere. Such set of data consists in vertical profiles of zonal and meridional components with sufficient vertical resolution and accuracy to study mean winds and planetary scale disturbances in the whole stratosphere and lower mesosphere from 15 to 50 kilometers altitude. The very first climatology of the mean wind has been obtained and compared with climatological empirical models such as the MSISE wind model and with the analysis of the European Center for Medium range Weather Forecast (ECMWF) (for the common vertical range 15-30km). This climatology relies on 3 years of measurements and the seasonal variation and the total day-to-day variability are reported. For a specific operation with dense measurements coupled with temperature measurements from a co-located Rayleigh Lidar, a detailed analysis of the planetary waves activity over OHP will be performed with specific focus on the frequency content for and phase mismatch between the different parameters.

GCM SIMULATION OF STRATOSPHERIC BACKGROUND AEROSOL

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Stratospheric aerosol has various effects on the global climate system. It disturbs the radiative balance and changes the chemical composition of the atmosphere due to heterogeneous reactions. Therefore, as one part of a chemical-microphysical model, a stratospheric aerosol model is implemented in the Hamburg climate model ECHAM4. This model treats the formation, the development and the transport of stratospheric sulfuric aerosol. The size distribution and the weight percentage of the aerosol is calculated dependent on the H_2SO_4/H_2O-concentration, temperature and pressure. Homogeneous nucleation, condensation (evaporation), coagulation, water-vapor growth, sedimentation and stratospheric sulfur chemistry are included. Additionally, the microphysical model is coupled to a tropospheric sulfur cycle. This sulfur cycle treats the natural and anthropogenic emissions, chemistry, dry and wet deposition and chemistry of DMS, SO_2 and SO_4^{2-}. Due to this combination of microphysical model and sulfur cycle, globally and seasonally different SO_2- and SO_4^{2-}-sources for stratospheric aerosol are taken into account. First results of the 3d-simulation show that the model is able to reproduce the observed surface concentration. The formation of new particles through homogeneous nucleation takes place in the lower stratosphere and in polar spring. Here results of a multiyear run are presented and compared to observations.

TRACE GAS MEASUREMENTS IN THE ARCTIC WINTER STRATOSPHERE WITH THE AIRBORNE SUBMILLIMETER SIS RADIOMETER

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The Airborne-Submillimeter-SIS-Radiometer (ASUR) measures thermal emission lines of stratospheric trace gases at submillimeter wavelengths. It is operated aboard the German research aircraft FALCON at flight altitudes of 10-12 km to avoid the absorption caused by tropospheric water vapor. Volume mixing ratio profiles can be retrieved from the pressure broadened spectral lines using non-linear least squares inversion algorithms. Measurement campaigns with respect to ozone depletion in the Arctic winter stratosphere have been carried out in yearly intervals since 1992 to investigate the distributions of the radical Chlorine monoxide (ClO), the reservoir species Hydrochloric acid (HCl), the chemically inert tracer Nitrous oxide (N_2O), and Ozone (O_3). A large dataset has been obtained which has been used to validate the 3D chemical transport model SLIMCAT inside, at the edge, and outside the polar vortex.

CLIMATOLOGY OF ARCTIC AND ANTARCTIC POLAR VORTICES USING ELLIPTICAL DIAGNOSTICS

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The climatological structure, and interannual variability, of the Arctic and Antarctic stratospheric polar vortices are examined by analysis of elliptical diagnostics applied to 18 years of potential vorticity data. The elliptical diagnostics define the area, center, elongation and orientation of each vortex, and are used to quantify their structure and evolution. The diagnostics offer a novel view of the well-known differences in the climatological structure of the polar vortices. There are substantial differences in the distortion of the vortices from zonal symmetry: the Arctic vortex is displaced further off the pole and is more elongated than the Antarctic vortex. While there is a mid-winter minimum in the distortion of the Antarctic vortex, the distortion of the Arctic vortex increases during its life cycle. There are also large differences in the interannual variability of the vortices: the variability of the Antarctic vortex is small except during the spring vortex breakdown, whereas Arctic vortex is highly variable throughout its life-cycle, particularly in late-winter. The diagnostics also reveal features not apparent in previous studies. For example, there are periods when there are large zonal shifts in the climatological locations of the vortices, and in early winter there are two preferred longitudes of the center of the lower stratospheric Arctic vortex.

MEASUREMENTS OF GRAVITY WAVE ACTIVITY AND THERMAL STRUCTURE IN THE ARCTIC STRATOSPHERIC VORTEX

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The stratospheric observatory in the Canadian High Arctic at Eureka (80°N,86°W) is ideally situated to observe processes which are associated with the dynamics of the polar vortex. Lidar measurements at Eureka have shown a clear pattern in the distribution of gravity wave activity and thermal structure within and around the vortex. Gravity wave activity is a maximum in the jet of the vortex and a minimum within the vortex core. The warmest region of the upper stratosphere is within the core while the coldest region is outside the vortex. These observations also indicate that there is an annual midwinter warming of the upper stratosphere within the core. Coincident with this warming is an observed increase in gravity wave activity in the jet. The distribution of gravity wave activity can be explained by the Doppler shifting and critical level filtering that is imposed by the background wind profile. We propose that increased gravity wave dissipation above the jet forces the flow toward the vortex core where it descends and warms by adiabatic compression.

ST3 Open session on the ionosphere and thermosphere

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OBSERVATIONS OF WAVE MOTIONS IN THE MESOPAUSE OF EARTH'S ATMOSPHERE WITH USING OF VERY LOW FREQUENCY SIGNALS.

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Two-frequency scheme of lower ionosphere electromagnetic sounding was used for investigations of atmosphere-ionosphere disturbances over period from Feb., 16, 1997 to Nov., 1997. Amplitude measurements were performed for impulsive signals at two frequencies, 11905 and 14881 Hz, from Russian VLF navigation system. The distance between transmitter (Krasnodar) and receiver (N.Novgorod, both in Russia) was 1500 km. As a rule, during daytime conditions, 3-4 hours after sunrise, visible sinuousform untiphase variations with periods of 1-10 min are observed in amplitude of signals. In accordance with VLF-waveguide theory, daytime reflection hights are equaled to 63-66 km, just bellow of the mesopause region. Due to the summation of waveguide modes the untiphase behaviour of amplitudes must be observed for signals at frequencies 12 kHz and 15 kHz and distance under consideration. During nightime conditions, when the reflection hights are increased up to 80-85 km and situated, in fact, within the mesopause or just above, periods af signal amplitude variations are increased essentially also, up to 1-3 hours, and have a clear cutoff, equaled to 8-10 min.

USAGE OF METEOROLOGIC AND IONOSPHERIC DATA FOR THE PURPOSES OF EARTHQUAKE PREDICTIONS

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In this article results of analysis of comparison of meteorogical and ionospheric data during Gissar earthquake are presented. The method of prediction of earthquake time based on the discovered phenomenon of violation of equilibrium state of temperature and pressure in atmosphere and ionospheric effects before earthquakesis. Simultaneous appearanse of anomaly phenomena in the atmosphere and ionosphere withness the common origin of them. Exposure of P-T shift equilibrium state function in atmosphere and anomalies in ionosphere can be reliable signal for rapid analysis of observation according to the complete set of methods of an earthquake short-term prediction. It showed that these effects observed 2-3 days before earthquakes.

LONG-TERM VARIATION OF THE HEIGHT OF THE MAXIMUM ELECTRON DENSITY IN THE IONOSPHERE

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The long-term variation of the height of the maximum electron density in the ionosphere hmF2 has been studied using the data of 17 Far-Eastern and American ionospheric stations. The stations are located in a limited region of geographical longitude both in the Far-Eastern and the American zone. The trend of hmF2(km/year) and the level of significance of the results has been determined for every station. It has been found that the trend of hmF2 seems to indicate a latitudinal variation, beginning with positive trends at northern high latitude followed by increasing negative trends from northern mid-latitudes to southern high latitudes. The seasonal and daily variations of the trend has also been established. The seasonal variation can be approximated by a curve showing maximum values in the winter months. The daily variation shows rather greater values by night, than by day. A preliminary explanation of the results obtained is also given.

DESCENT RATES IN PMSE TYPE LAYERS OBESERVED BY THE UK MST RADAR AT ABERYSTWYTH

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The routine measurements made during June and July of the mesopause region over Aberystwyth (52.4°N, 4.1°W) for the years 1990 to 1994 often contain PMSE type returns. Of the 96 such days available to the author 44 contained only a single layer that persisted for at least half an hour. In another 9 days two distinct layers separated in altitude were observed. The remaining 43 days consisted of PMSE type returns that persisted for only short periods. On 35 days the single layer was found to descend. The descent rate being in the range 0.04km/h to 2.90km/h, with mean 0.88km/h. The other 9 single layers were found to ascend with a maximum ascent rate of 0.34km/h. In the twin layer case the descent rate of the highest layer was in the range 0.71km/h and 2.13km/h, with mean 1.08km/h. It is noted that the mean descent rate in both the single and twin layer case is close to the descent rate for the diurnal tide, and that the maximum descent rate is close to that for the semi-diurnal tide. However, where there are two layers their vertical separation, of approximately 12km, are somewhat less than the expected vertical wavelength of the diurnal tide. An explanation could be that there is a general slowing of the descent rate as the tidal phase front passes down through the mesosphere resulting in a convergence of the two layers. This has been found in other observations and models in the published literature where gravity wave breaking in the mesosphere slows the descent of the tide with consequent reduction in the vertical wavelength. Evidence for this convergence in the MST data is provided by the fact that in general the lower layer descends more slowly than the upper layer. It would thus appear that PMSE layers over Aberystwyth usually have a dominant diurnal component, though there may be on occasions a strong semi-diurnal component, and a background of gravity wave activity that can cause ascent or slowing of the descent of the layers.

EFFECTS OF A MAGNETIC STORM ON THE EQUATORIAL IONOSPHERE, OBSERVED BY HF RADAR DURING THE IEEY

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During the IEEY, ionospheric measurements have been performed using a high resolution HF radar at Korhogo in Ivory Coast (9°24'62"N, 5°37'38"W). Irregularities of the daytime equatorial ionosphere have been intensively studied during two campaigns in April-July 93 and October-November 94. They are formed by intense kilometric irregularities at 100-115 km in the electrojet region and weak irregularities in a typical equatorial intermediate region at 150 km. Their characteristics are strongly dependent on the magnetic conditions. The purpose of this paper is to present a detailed observation of the effects of a magnetic storm on the structure of these irregularities. One of the most striking effect is an increase of the irregularities amplitude correlated with increases of the magnetic field measured at ground, irregularities disappear when the magnetic field decreases. Doppler measurements have been used for providing the electrojet electric field. The results are discussed in terms of the influence of the external dynamo on the equatorial ionosphere.

HEIGHT DEPENDENCE OF THE GRAVITY WAVE ACTIVITY CALCULATED FROM RAPID SEQUENCE IONOSPHERIC VERTICAL SOUNDING

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The results of two campaigns of rapid sequence (repetiton time 5 minutes) ionospheric vertical soundings measured at Pruhonice observatory (15E, 50N) are used for computing the ionospheric parameters in the height range of 150-250 km. Both campaigns (10-17 October 1996 and 27 October-7 November 1997) and were run under low solar and geomagnetic activity conditions. Data were well usable for evaluating the gravity wave activity, especially during daytime. Computed ionospheric parameters are used for evaluation of the height dependence of acoustic gravity wave activity and dissipation of the gravity waves with height.

A DIGITAL IONOSPHERIC STATION IN THE OBSERVATORY LOPARSKAYA

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During many years there was an ionospheric station in the Geophysical Observatory Loparskaya (LOP, φ=68.25^{0}N, λ=33.08^{0}E; Φ=64.52^{0}N, Λ=113.9^{0}E; L=5.2). A photographical method was used and it was decided to adapt an ionospheric complex "Bazis" as a modern vertical ionosonde. The main problem was to replace the old system of information sampling by using modern hardware and to create new software. It has been done and we have now a digital ionospheric station of a vertical sounding with modern software and hardware. The range of working frequencies is 0.3÷39.999 MHz. The sounding frequency changes automatically with a discrete step chosen beforehand: 1, 5, 10, 20, 25, 50, 100 kHz. A working cycle of sounding includes 400 successive frequencies which change with a chosen step. Duration of pulses is in the range 25÷800 mks, a repetition frequency can be chosen in the range of 1÷50 Hz. Pulse power is about15 kW.

HF DOPPLER PROBING OF IONOSPHERIC PERTURBATIONS WHICH ACCOMPANIED THE SPACE SHUTTLE ATLANTIS LAUNCH WITH A GEOMAGNETIC STORM AS A BACKGROUND

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Spectral analysis of the Doppler shift $f_d(t)$ has revealed that in 45 to 50 min after the lift-off on May 15, 1997, in a $z \sim$250 to 300 km region a 50%, 30% and 100% increase in T =13-, 32-, and 64-min period harmonics, respectively, occurs in the HF Doppler spectrum. The duration of quasi-periodic perturbations is more than an hour. The quasi-periodic perturbation amplitude $\Delta N/N \approx$ 2%. It is possible that the perturbations were caused by burn of the Orbital Maneuvering System engines triggering processes observed in the ionosphere. The apparent speed is 29±9 km/s. The authors have been supported by STCU Grant 471.

OBSERVATIONS OF IONOSPHERIC *D* REGION PERTURBATIONS WHICH ACCOMPANIED THE SPACE SHUTTLE ORBITER ATLANTIS LAUNCH WITH A GEOMAGNETIC STORM AS A BACKGROUND BY PARTIAL REFLECTION TECHNIQUE

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Observations of possible global processes in the lower ionosphere which accompanied the launch of the Space Shuttle orbiter Atlantis on May 15, 1997, are presented. Quasi-periodic perturbations in the electron number density of $\Delta N/N \sim$ 30 to 70% are determined with magnitudes of their time delays of the order of 45 to 55 min, those of quasi-periods of tens of minutes, and durations of 1 to 2 hours. They could be due to pulsating 10^2 to 10 keV electron fluxes of $\sim 10^6$ to $4 \cdot 10^7 m^{-2}s^{-1}$ from the magnetosphere. The authors have been supported by STCU Grant 471.

ON THE POSSIBILITY OF ENERGETIC PARTICLE PRECIPITATION FROM THE MAGNETOSPHERE INTO THE MIDDLE LATITUDE IONOSPHERE

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Observations of transient processes in the lower ionosphere made by different techniques (partial reflection, magnetometer, etc.) are analyzed. Anthropogenic and natural perturbations in the ionosphere could be accompanied by the precipitation of energetic particles. Parameters of electron fluxes (particle fluxes of $p \sim 10^6$ to $10^8 m^{-2}s^{-1}$, energy fluxes of $\sim 10^{-8}$ to $10^{-7} Jm^{-2}s^{-1}$, etc.) are estimated. The precipitating electrons cause an increase of $\sim 10^5$ to $10^7 m^{-3}s^{-1}$ in the rate of production of ionization. A comparison of flux parameters in the high- and midlatitude ionosphere is made. The authors have been supported by STCU Grant 471.

AN ION-MOLECULE MECHANISM FOR THE FORMATION OF NEUTRAL SPORADIC LAYERS OF SODIUM AND IRON

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Sporadic neutral layers are thin, highly concentrated layers of metal atoms that appear quite suddenly in the lower thermosphere. Although a number of theories have been advanced to account for the metal reservoir and the mechanism that triggers this very puzzling phenomenon, there is strong evidence that the reservoir is metal ions in sporadic-*E* layers. We have therefore carried out a laboratory study, using a fast flow tube and a novel laser flash photolysis technique, into the chemical pathways by which Na^+ and Fe^+ are converted to neutral atoms. This work has shown that the neutralisation kinetics of these ions in the MLT region is in fact rather complex. Significantly, the lifetime of Na^+ changes rapidly from more than a day above 100 km to just a few minutes at 90 km. A model describing the neutralisation of Na^+ and Fe^+ in a descending sporadic-*E* layer demonstrates that the ion-molecule mechanism fulfils most of the criteria for producing sporadic metal layers, including the observed differences between Na and Fe.

LONG-TERM TRENDS OF THE IONOSPHERIC AND TERMOSPHERIC PARAMETERS AND THEIR MUTUAL RELATION

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During the recent years publications appeared in which long-term trends of various ionospheric and thermospheric parameters had been detected. Original data on the trends of the F2 layer critical frequency foF2 and the E region ion composition are presented. The method of correct derivation of trends, including use of relative values instead of absolute ones, is discussed. It is demonstrated that the correct treating of the initial data series for the foF2 data improves significantly the statistics and eliminate the seasonal effect in the foF2 trends found earlier. An importance of proper choice of the solar cycle periods to get rid of the hysteresis effect and to reduce the data scatter in deriving the foF2 trends is demonstrated. An attempt to consider jointly the trends in the thermospheric and ionospheric parameters (foF2, foE, hmF2, the E region ion composition, number of ionospheric storms, occurrence frequency of F-spread) in the scope of the ionosphere formation theory is made.

COMPUTATIONAL ALGORITHM FOR SOME PROBLEMS OF IONOSPHERE WAVE INTERACTION

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The propagation of powerful electromagnetic waves is described in terms of nonlinear equations of the evolution type. We consider the computational simulation of this nonlinear problem. Disadvantages of the numerical approximation can lead to the appearance of high harmonics and the physical instability can increase these parasitic harmonics. Thus, we can obtain the picture which is absolutely not correspond to the physical phenomenon. We suggest the computational algorithm which is based on the combination of the decomposition method and the theory of the generalized functions. The numerical algorithm is consist of two stages: first one include the differential operator across the wave propagation direction but, it is not contain nonlinearity; second one include all nonlinear terms but not transversal derivatives. The first step is a classic step for the linear propagation and diffraction problem. The second step leads only to a variation of the phase but not the amplitude of the wave. It is not difficult to argue that the second step is absolutely stable if the nonlinear terms depend only from the modulus of the desired complex function. The physical sense of such separation is to separate the process of the linear propagation from the process of the nonlinear distortion. In order to avoid the parasitic harmonics, we can use for the first stage the approach of the generalized function theory. For this aim, we introduce the system of base functions and transfer the differentiation from the desired function to the base functions.

A STATISTICAL COMPARISON OF MEASURED VELOCITIES FROM THE CUTLASS SYSTEM AND THE EISCAT UHF RADAR

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Comparison is made, on a statistical basis, of measurements of irregularity drift speed made by the CUTLASS HF radars, sited in Finland and Iceland, and F-region ion velocity measurements from the EISCAT UHF radar. Since the CUTLASS radar facility commenced operation, in 1995, a significant amount of simultaneous CUTLASS and EISCAT measurements have been collected; it is, therefore, now timely to compare statistically the velocities measured by the two radar systems. Line-of-sight measurements from both the CUTLASS Finland and Iceland radars are compared to the component of the ion vector velocity, yielded by the tristatic EISCAT UHF radar, along the appropriate CUTLASS radar beam.

INTERPRETATION OF EQUATORIAL IONOSPHERIC IRREGULARITIES OBSERVED BY HF RADAR IN THE UPPER E REGION

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The purpose of this paper is to present new interpretations of observations performed during the International Equatorial Electrojet Year (IEEY) in Ivory Coast (Korhogo, 9°24′62″N, 5°37′38″W, 4° dip angle) with high precision H.F. vertical soundings. We observed irregularities in the E, upper E and F1 regions, during daytime and magnetic disturbed periods. We try here to explain the irregularity creation process. In a first part we will present existence conditions, in a second part we will examine some hypotheses for different kinds of irregularities.

SIMULTANEOUS EISCAT/STARE OBSERVATIONS OF THE UNSTABLE E-REGION

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A relatively large data set of simultaneous EISCAT/STARE observations are used to test a number of theoretical predictions concerning the E-region current instability (Farley-Buneman). The data covers periods of 6 hours (18-24 UT) on 17 separate days during March and April 1988. EISCAT provided both a good determination of the electric field and high-resolution measurements of the ionospheric parameters in the E-region, while the two coherent radars from STARE measured the phase velocity of the unstable waves along two different directions.
The onset of instability is clearly identified and the instability cone separating two regimes of turbulence in the plane perpendicular to the magnetic field is defined. The instability threshold is studied as a function of the electric field, the temperature of the plasma, and the level of neutral wind activity (particularly the effects of tides), together with the evolution of the turbulence inside and outside the instability cone, and the associated turbulent heating of the surrounding plasma, as functions of the strength of the convection electric field.

MAGNETOSPHERIC AND IONOSPHERIC DISTURBANCE DYNAMO EFFECTS IN THE LOW- AND MID-LATITUDE IONOSPHERE

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The ionospheric plasma drifts are strongly affected by geomagnetic activity. We use Ion Drift Meter data from the DE-2 satellite and incoherent scatter radar observations to examine the low- and mid-latitude ionospheric disturbance electric field patterns. The average disturbance drift patterns obtained from these data are generally in good agreement with results from global convection and ionospheric disturbance dynamo models. However, these observations also indicate large variability on the electric field disturbance patterns. In this talk we concentrate on the possible effects of IMF B_y, season, solar cycle, and longitude on the low- and mid-latitude ionospheric perturbation electric fields during disturbed conditions and on their effects on the generation of ionospheric plasma waves.

INTRADIURNAL OSCILLATIONS IN ANTARCTIC LOWER THERMOSPHERE WINDS: SOUTH POLE OBSERVATIONS AND GLOBAL IMPLICATIONS

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Meteor radar wind measurements were made from the South Pole from January 19, 1995 through January 26, 1996, and from November 21, 1996, through January 27, 1997. The radar measures meridional wind speeds in four volumes of space located near 95 km altitude, 88 deg latitude, and along the 0, 90E, 90W and 180 deg longitude meridians. Observed intradiurnal oscillations which are westward-propagating with zonal wavenumber one fall into two classes: (a) a 12-hour oscillation which dominates during non-winter months; and (b) shorter-period oscillations which appear only during the winter. During the austral winter of 1995, six intradiurnal wave "events" occurred which met our statistical significance criterion. Wave periods ranged between about 7.0 and 10.5 hours, with wave amplitudes ranging between 10 and 15 m/sec. These events are examined in detail, and numerical simulations using the Global Scale Wave Model are presented which provide some indication of the latitudinal and vertical extent of the oscillations.

ENHANCED ION ACOUSTIC FLUCTUATIONS AND ION OUTFLOWS IN THE UPPER IONOSPHERE

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Number of observations showing enhanced ion acoustic echoes observed by mean of incoherent scatter radar have been reported in the litterature. The received power is extremely enhanced up to 1 or 2 orders of magnitude above usual values, and it is mostly contained in one of the two ion acoustic lines. This spectral asymmetry and the intensity of the received signal cannot be resolved by the standard analysis procedure and often cause its failure. As a result, and in spite of a very clear spectral signature, the analysis is unable to fit the plasma parameters inside the regions of ion acoustic turbulence. Enhanced ion acoustic fluctuations are associated with ; enhanced electron temperature and large field-aligned bulk ion outflows from the topside ionosphere Although unavailable from the standard analysis procedure, the plasma description inside turbulent regions remains a crucial information to understand the ion acceleration process related to enhanced ion acoustic echoes. We will present in this talk European Incoherent Scatter radar EISCAT observations of large ion outflows associated with the simultaneous occurence of enhanced ion acoustic echoes. From the very clear spectral signatures of this echoes, a method will presented to extract some kind of estimates or informations on the plasma. Finally, estimates of the electron temperature and of the ion drift are used to study the possible implications on the plasma transport inside turbulent regions.

A NEW UPSHIFTED SPECTRAL STRUCTURE IN STIMULATED ELECTROMAGNETIC EMISSION SPECTRA, OBSERVED BETWEEN ELECTRON CYCLOTRON HARMONICS

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We present detailed experimental results concerning features of the broad upshifted structure (BUS) which extends in the stimulated electromagnetic emission spectra up to $90 - 170$ kHz above the pump wave frequency. The BUS properties have been studied in the frequency range between the 3rd and 5th electron cyclotron harmonics ($f_{ce} \simeq 1350$ kHz in our measurements). It is observed that the generation of the BUS occurs in the pump frequency ranges from 4.3 MHz to 4.8 MHz and from 5.55 MHz to 6 MHz, with a maximum intensity at about 4.55 MHz and 5.6 MHz, respectively. The BUS is found to be induced in the vicinity of the upper hybrid resonance level for the pump wave. The threshold pump power for the BUS generation is about 5 MW ERP. The dependence of the BUS spectral features on the pump frequency and pump power, as well as their temporal development and decay under different ionospheric conditions, are investigated. The experiments were performed at the Sura heating facility ($56°N, 46°E$, Nizhny Novgorod, Russia) by modification of the ionospheric F region using a HF ordinary mode pump wave.

TWO COMPONENT NATURE OF BROAD UPSHIFTED MAXIMUM EMISSION FROM THE HF MODIFIED IONOSPHERE

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We have studied at the Sura heating facility ($56°N, 46°E$, Nizhny Novgorod, Russia) the structure of the BUM emission in the SEE spectrum and found that the BUM includes two different components, BUM_1 and BUM_2. Generation of the BUM_1 occurs when the pump frequency, f_0, is in the immediate vicinity of the electron cyclotron harmonic, that is for $\delta f \equiv f_0 - 4f_{ce} = -20$ to $+60$ kHz. Its intensity is highest for $\delta f \simeq 0$. This component is characterized by a weak dependence of its peak frequency, Δf_{BUM_1}, on the pump frequency f_0. In contrast, the peak frequency of the BUM_2 significantly increases with f_0, approximately satisfying the equation $\Delta f_{BUM_2} = \delta f$ for $\delta f \geq 40$ kHz, while for smaller δf this dependence may be weaker. The BUM_2 peak intensity has its highest value for $\delta f \simeq 30 - 40$ kHz, where the occurrence of multiple maxima (up to three, as a rule) is observed in the spectra. We find that the BUM_2 is generated in the vicinity of the upper hybrid resonance level, i.e., where the local upper hybrid frequency, $f_{uh} = (f_{pe}^2 + f_{ce}^2)^{1/2}$, equals the pump frequency f_0.

FIELD-ALIGNED ION FLOW EVENTS FROM THE IONOSPHERE OBSERVED BY THE EISCAT VHF RADAR

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We have determined statistically the spatial distribution of field- aligned ion flows and their temporal developments by using Common Program-7 (CP-7) data obtained from the EISCAT VHF radar system at Tromsø, Norway. Tromsø is located mostly in the closed magnetic field line region. We have found that field-aligned ion flows are sporadic phenomena and both ion outflows and inflows occur at all MLTs, but ion outflows dominate over ion inflows in terms of their occurrence and velocities. Representative samples of these ion outflow/inflow events indicate that ion momentum is not solely determined by effective (ambipolar) ion pressure gradient, gravity force, neutral friction and inertia.

VARIATIONS IN THE ELECTRON COLLISION FREQUENCY AND ELECTRIC FIELDS IN THE LOWER IONOSPHERE AT MIDDLE LATITUDES

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The analysis of measurements made by the partial reflection technique at the lower edge of the ionosphere has provided the distribution of effective electron collision frequency magnitudes derived with taking into account the kinetic effects. An assumption is made that this distribution is affected during periods of strong electric fields. A new technique for deriving these electric fields from the data on effective electron collision frequencies is developed. The results of investigations of electric fields obtained from this technique during 1978 to 1997 at Kharkiv State University are presented. The authors have been supported by STCU Grant 471.

RECENT ADVANCES IN INCOHERENT SCATTER RADAR MEASUREMENT CAPABILITIES OF THE TOPSIDE IONSOPHERE AND PLASMASPHERE AT ARECIBO OBSERVATORY

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New measurements of light ions in the topside ionosphere over Arecibo will be presented. We will discuss the altitude and temporal variations of the three major ion species in the topside ionosphere (O^+, H^+, and He^+). The ISR spectra were reduced using a a non-linear least squares fitting algorithm which allowed for Te, Ti, $[O^+]$, $[H^+]$, and $[He^+]$ to be free simultaneously. One of the more striking features of the ion distributions is the formation of a He^+ layer during the night at altitudes near the O^+/H^+ transition region. In addition we will present results of independent velocity (V_{O^+}, and V_{H^+}) and temperature (T_{O^+}, and T_{H^+}) measurements.

METHOD FOR RECONSTRUCTION OF DRIFT VELOCITY FIELD IN IONOSPHERE BY SATELLITE RADIOSOUNDING

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Methods of ionosphere radiotomography are under intensive development in plurality of recent works. According to all of these methods ionosphere is presumed to be at rest. In other words the motion of ionosphere medium during satellite travel is neglected. However electron drifts considerably effect on measured radio signal and consequently on reconstruction results. By this means one can formulate another problem: determination of drift velocities by ground-based measurements of doppler shift. Because of Doppler effect the shift of radiosounding frequency is proportional to projection of electron drift velocity onto the radio ray direction. Discussed method is based on tomography approach for determination of drift velocities field in the plane of satellite orbit. (For this reason the radio source and receivers must be rather stable and sensible o provide adequate precision of data.) To solve inverse problem of reconstruction of ionosphere velocities field we assume geometrical optics approximation and existing information about ionosphere electron density distribution.

SIMULTANEOUS OBSERVATIONS OF ENHANCED ION SPECTRA AND STRONG PLASMA LINES WITH THE EISCAT UHF RADAR SYSTEM.

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We present the simultaneous observations of strongly enhanced ion spectra and plasma lines from a Norwegian Special programme EISCAT experiment conducted in summer conditions during a sunspot minimum. We believe the events presented are the first observations of simultaneous enhancement of the ion spectrum and the plasma lines. The observations are also some of the strongest enhancements observed of natural plasma lines.
Explanations in terms of ordinary enhancement mechanisms, i.e. particle precipitation, photoelectrons etc. are discussed. as are explanations based on different instabilities previously treated in the litterature. In particular. the possibility of cavitating Langmuir turbulence is discussed.

CLIMATOLOGY OF THE MESOPAUSE REGION SEMIDIURNAL TIDE OVER CENTRAL AND EASTERN EUROPE

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Wind measurements of 5 European sites using different systems (Juliusruh, MF radar, 55°N, 14°E; Collm, LF D1 wind profiler, 52°N, 15°E; Kharkov, meteor radar, 50°N, 37°E; Obninsk, meteor radar, 55°N, 37°E; Kazan, meteor radar, 56°N, 59°E) are used to set up a climatology of the semidiurnal tide in the mesopause region over Central and Eastern Europe for the latitude range between 50°N and 56°N. Intercomparison of amplitudes and phases generally shows excellent agreement of the results from the different measuring systems. The longitudinal variation of the semidiurnal tide is small. The results are compared with an empirical model of the semidiurnal tide.

DOPPLER FREQUENCY INTERPRETATION OF INCOHERENT SCATTER PLASMA LINES

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In an incoherent scattering plasma line experiment, the phase velocity of both upgoing and downgoing Langmuir waves can be estimated. These two phase velocities are the high frequencies solutions of the plasma dispersion relation for longitudinal waves. The moment expansion of this plasma dispersion relation is reviewed. It is shown, in particular, that only the flux of the kinetic energy which is parallel to the scattering direction has to be accounted. Up- and downshifted plasma lines incoherent scatter data are presented and the Doppler frequency asymmetry is discussed in terms of the heat flow contribution and the mean drift velocity contribution.

NONLINEAR INTERACTION OF PLANETARY WAVES AND TIDES AS SEEN FROM MIDLATITUDE UPPER MESOSPHERE/LOWER THERMOSPHERE WIND MEASUREMENTS AT COLLM, GERMANY (52°N, 15°E)

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From daily estimates of the prevailing wind and the semidiurnal tide in the upper mesosphere/lower thermosphere at about 95 - 100 km height long-term variations at the time scales of planetary wave periods can be detected. The long-term measurements at the Collm Observatory of the University of Leipzig, Germany, provide a climatology of these waves as they can be seen in the oscillations of the prevailing wind, from measurements of the years 1981 - 1996. Maximum variance is generally found at periods of more than 10 days. Variations of the semidiurnal tidal amplitude in the same period range are also found, that are be due to the superposition of secondary waves that are originated by nonlinear interaction between the semidiurnal tide and planetary waves. From regression analyses the existence of these secondary waves is indicated, which supports this interpretation. A comparison of tidal and prevailing wind long-period variability shows that planetary waves are regularly connected with a modulation of the tides.

THE POLAR BLOBS BY YAKUT MERIDIANAL CHAIN IONOSONDE DATA

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By ground-based data of Yakut meridianal chain ionosondes the signatures of the polar blobs in nigthside MLT sector are established. In vertical and oblique ionograms these signatures show as follows: (1) increased critical frequency of the trace (up to 12 MHz), (2) fmin-parameter is 1.0-1.5 MHz and, (3) no sporadical type of the traces from E-region. The seasonal course of the polar blob occurrence have been a maximum during winter months.

THE STRUCTURE OF THE NIGHT-TIME IONOSPHERIC E-REGION IN THE SUBAURORAL INTENSE ELECTRIC FIELD STRIP TAKING INTO ACCOUNT THE REAL TILTE OF GEOMAGNETIC FORCE LINES

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The structure of the night - time ionospheric E-region in the subauroral intense electric feld strip is numerically modeling taking into account the real tilte of geomagnetic force lines. The calculated electron density distribution is substantially different from the results obtained before by Banks and Yasuhara (Geophys.Res. Lett., 5, p.1047, 1978) with assumption of vertical geomagnetic force lines. The difference can be up to a factor of 10.

REDUCTION TECHNIQUE IN IONOSPHERE RADIOSOUNDING

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We present an improved data processing technique for the problem of ionosphere ray radio tomography using methods of mathematical interpretation (mathematical reduction). The existing methods of electron density reconstruction are based on solving the system of linear equations corresponding to integrals over radio ray trajectories in ionosphere. The solution gives essentially unbiased estimate for field of electron density. However in presence of high noise level during measurement such solution can be ineligible. To reduce noise influence we propose to construct biased estimate. The minimal bias (under certain conditions) can lead to significant repression of noise. To construct linear matrix operator expressing physical model we assume validity of geometric optics and existence of some a priori information about density to be reconstructed (predictions of electron density profile and stochastic characteristics of noise). The linearity of this operator is the main requirement for appliance of reduction technique. Final solution is given as multiplication of several matrixes according to selected principle (biased or unbiased reduction). The results are in ready form for computer simulation or processing of satellite radiosounding experimental data.

THE MPAE FABRY-PEROT INTERFEROMETER FOR NEUTRAL ATMOSPHERE AND IONOSPHERE INTERACTION STUDIES WITH EISCAT

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The EISCAT incoherent-backscatter radar system (KST) is capable of measuring many ionospheric parameters. Neutral atmospheric parameters can only be indirectly inferred using additional models and assumptions. Therefore, it is highly desirable to measure both types of parameters simultaneously. For the purpose of studying ionosphere-atmosphere interactions, a new Fabry-Perot interferometer (FPI) has been built. It is located in Skibotn, Norway, about 50 km from EISCAT. The instrument is capable of measuring line-of-sight neutral wind speeds and temperatures from the Doppler shift and broadening, respectively, of auroral/airglow emissions. Thermospheric or mesospheric measurements are made by selecting different wavelengths. Measurements are made automatically and continuously for all dark-sky periods. A study of the neutral wind dynamo effect on the ionospheric electric field has been completed. Current work includes comparing neutral winds between FPIs at different locations, comparing neutral winds measured using different emissions, bi-static wind measurements and comparing ion to neutral temperatures. Future studies include improved determination of the ion-neutral collision frequency and improving radar models of the neutral wind.

A COMPARISON OF AURORAL OPTICAL IMAGES, RIOMETER ABSORPTION PATTERNS AND EISCAT RADAR DATA

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Recordings of auroral emissions at 557.7 nm are made from Skibotn, Norway (69.35° N, 20.36° E) using the Digital All-Sky Imager (DASI). The data are calibrated and transformed into a 520x520 km geographic grid every 10 s. The images give estimates of the precipitation patterns of soft electrons (< 10 keV). Recordings of cosmic radio noise absorption at 38.2 MHz are made from Kilpisjarvi, Finland (69.05° N, 20.79° E) using the multi-beam Imaging Riometer for Ionospheric Studies (IRIS). The data are calibrated and transformed into a 240x240 km rectilinear grid every 1 s. The images give estimates of the precipitation patterns of hard electrons (> 10 keV). The EISCAT incoherent-backscatter radar (69.59° N, 19.23° E) makes good measurements of the electron density profile with altitude from which estimates of the energy spectra of precipitating electrons can be made. For the night of 13/14 February 1996, the morphology of optical emissions and absorption patterns is compared including, in the common field-of-view, the particle energy spectrum.

COMPARISION OF NEUTRAL AND ION PARAMETERS IN THE HIGH LATITUDE E- AND F-REGION OBSERVED BY THE MPAE-FPI AND EISCAT

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During the last winter season neutral winds and temperatures were measured in the E- and F-region by the MPAE-Fabry-Perot-Interferometer (FPI) located at Skibotn, about 50 km from EISCAT. From the observation of different auroral and airglow emission lines (630 nm, 557.7 nm and 843 nm), parameters are measured from different altitude ranges in the ionosphere. Simultaneous observations of ionospheric parameters were made by EISCAT. Results and comparisons from both devices will be presented and discussed.

THE TECHNOLOGY OF SIGNAL AND DATA PROCESSING IN MODERN DIGITAL IONOSONDE.

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The modern technology of digital signal processing and methods of sounding data processing are realized in Russian new generation of digital ionosondes. They open new opportunities in the diagnostics of middle-scaled, as well as small-scaled inhomogeneuities of ionosphere's plasma in the interval of heights from 100 up to 500 km. The methods of signal and data processing into time-domain region are considered. They are based on use of results of monostatic radio sounding. Special attention is attended to joint estimation of Doppler shift of coherent component of a signal and relative intensity incoherent component. It is marked, that the detection and estimation of the spatial and time scales of inhomogeneuities in various intervals of heights of ionosphere requires application of various modes and characteristics of radio sounding as well as methods of spectral-correlation analysis appropriate to them.

METHODS OF THE NEARSPACE ENVIRONMENT TOMOGRAPHY

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Modern tomographic and occultation technique for ionospheric/ atmospheric profiling has essential limitations. In many cases distant complicated troponosphere and ionosphere structures (in particular, layer formations, troughs, wave disturbations, etc.) influence greatly reconstructed profilies. A variant of atmosphere-ionosphere tomography using GPS/GLONASS and the network of ground-based receivers is considered. It is necessary to take into account temporal variations of atmosphere and ionosphere because of small angular satellite velocity. Using the network of ground-based receivers improves the horizontal resolution and the accuracy of reconstructed vertical profiles. Two-level satellite tomography variant has more opportunities. It is reasonable to use 2-3 frequencies of receiver-transmitter systems in the range of 150-800 MHz. for realization of Atmosphere - Ionosphere - Protonosphere tomography. The computer simulation results showed that the receivers spaced by hundreds of kilometers are sufficient for most of practical problems.

RADIOPHYSICS INVESTIGATIONS OF IONOSPHERIC DISTURBANCES CAUSED BY OPERATED GROUND-BASED ACOUSTIC RADIATION.

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This report is devoted to the experiment of local ionosphere disturbances by low-frequency (LW) atmospheric acoustic waves (AAW) radiated by special operated based-ground acoustic generator (GAG). Discovering and investigation of ionosphere responses has been fulfilled by ground-based radiophysical instrumentation on base of decameter radiotelescope URAN-3 (Lviv, Ukraine). The following distant ionosphere diagnostic physical method's ware realized: radiotwinkles method during cosmic radiosources observation, methods of one-jumped inclined sounding of ionosphere and volume scattering on ionosphere plasma by radio waves of ground-based S.W.radio stations. It is shown experimentally possibility of the excitement of the ionosphere by acoustical energy approximately $2*10^6$ J on earth's surface. It is shown also that in the process of acoustical-electromagnetic interaction different physical mechanism takes place. Such as: shaping of artificial ionosphere turbulence with selffocusing properties, increase of the transparency of the ionosphere for cosmic radio waves caused by LW AAW, AAW transformation in plasma waves by their synchronizing, etc. Obtained result opens a new possibilities of physics modeling of the acoustic channel of lithosphere - atmosphere - ionosphere connections by ground means.

SEISMO-IONOSPHERIC EFFECTS UNDER THE INFLUENCE OF THE POWER SEISMOVIBRATOR TO THE LITHOSPHERE

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The synchronous disturbances on the ionosphere were registered by the doppler sounding at the "Klyuchi" station (Institute of geophysics, Novosibirsk) when the seismic vibrator with 100 tons force amplitude mounted at the "Bistrovka" testing area of Siberian Branch of SB RAS (Novosibirsk) is operated. The vibrator generated the seismic oscillations in the sweep-mode with the frequency change from 6 to 9 Hz during about 45 min. The observed disturbances appeared as a outside frequencies in the doppler spectrum. They drifted synchronously with seismic sweep-signal frequency with some time delay. The effect was noted during the daytime using the reflections from stable E-layer on the height about 100 km. It was absent during the night when the radioreflections are obtained for the sporadic Es- and F-layers. The distance between the ionosonde and vibrator is amount to about 50 km. The time delay between the initial sweep-signal and the its corresponding appearance in the ionosphere is estimated to 7-8 minutes. This is agreed with the time interval of the acoustic signal propagation to the radioreflection heights. It is noted that the similar infrasonic and seismic sweep-signals were detected by the ground measurements at the "Klyuchi" station.

HST DETECTION OF TERRESTRIAL DEUTERIUM

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We observed Mars at 1212-1218 Å with resolution of 0.07 Å during 1.57×10^4 s using the HST Goddard high-resolution spectrograph. The observation revealed both Mars' and Earth's D Ly-α lines. The telluric line zenith intensity is 17 ± 6 R (Rayleighs) at 600 km. To reproduce the measurement, we construct a model with [HD] = 1.2×10^5 cm^{-3} and [D] = 7.2×10^4 cm^{-3} at the lower boundary of 90 km. These values are obtained from the H_2 and H densities in Allen et al. (*JGR 89,* 4841, 1984) and the HD/H_2 and D/H enrichments relative to HDO/H_2O in Yung et al. (*Icarus 76,* 146, 1988). HD forms D in reactions with O, O^+, and $O(^1D)$. Effusion (escape) velocity V is the model parameter. The calculated intensity is 246 R for V = 0.008 cm/s (thermal escape at solar minimum, $F_{10.7\,cm}$ = 70, T = 736 K) and agrees with the measured value for the nonthermal escape velocity of V = 125 ± 25 cm/s. We applied our model to the previous detections of deuterium by Bertaux et al. (*Nature 309,* 771, 1984; *GRL 20,* 507, 1993) using deuterium absorption cells, and found $V \approx 300$ cm/s for the conditions of their observations in 1983. Our model for hydrogen agrees with the OSO-5 and AE measurements at solar minimum for V = 800 cm/s which exceeds the thermal escape velocity by an order of magnitude and results in the hydrogen escape rate of 2.6×10^8 cm^{-2}s^{-1} .

ON THE PLASMA IRREGULARITIES GENERATED BY NEUTRAL AIR TURBULENCE IN THE LOWER IONOSPHERE

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Plasma density fluctuations can be produced in the lower ionosphere as a result of turbulent motions of non-ionized gas in which a dilute quasi-neutral plasma is submerged. In the present report such a situation is treated by use of the system of 3-fluid equations. From this system an equation relating the plasma density fluctuations with the turbulent velocity field of neutrals is derived taking into account the conditions of lower ionosphere. To obtain an expression for the fluctuation spectrum the method of renormalized perturbation theory is applied. The obtained expression shows that the spectrum of irregularities is close to the Kolmogorov-type power law although some departures from a simple power law with a constant power index may exist. The rms density fluctuation level predicted theoretically is in fairly good agreement with the observed values.

PREDICTOR SCHEME FOR THE EISCAT DATA PROCESSING

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Through a statistical study, we have recently shown that the EISCAT data may be well described with an Auto Regressive filter. The electron density as well as electron and ion temperatures can then be one-step predicted, with a full time/height profile analysis. This scheme is now used in order to deduce the ion composition from the measurements. At each dump, a parameter amongst Ne, Te, Ti or composition is predicted, while the others are fitted. Step after step, the predicted parameters keeps changing. This method is discussed and results are shown in different solar and magnetic conditions, and compared to the standard analysis and to different models of ion composition.

ELECTRON AND ION TEMPERATURES DEPENDANCE OF THE ELECTRIC FIELD ABOVE EISCAT OVER A FULL SOLAR CYCLE

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Eleven years of common and special EISCAT experiments have been processed in order to deduce the behavior of the electric field. Indeed, this parameter is not always measured, and is often needed for the comprehension of the ionosphere. We show the correlation between the electric field and different parameters, densities or temperatures at different height. We then show that the more pertinent parameter correlated to the electric field is the difference between ion and electron temperature at 130 km, and propose a simple fitted law in order to estimate the electric field (when not measured) from this difference.

VHF radar and MF/HF dynasonde observations during Polar Mesosphere Summer Echo conditions at EISCAT

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The EISCAT VHF radar (224 MHz) and the EISCAT dynasonde (1-10 MHz) were operated simultaneously during a polar mesosphere summer echo (PMSE) event on 22 June 1994. We investigate the echo characteristics revealed by these two instruments. The antenna of the VHF radar was set 10! off zenith to the north for both transmission and receiving, while the dynasonde was operated with vertical beam to obtain ionograms every 3 minutes. The range-time intensity variation of the VHF radar PMSE is studied, which is characterized layered structures. The intensity profiles are quite intermittent which shows similarity to the echoes recorded by the dynasonde. To study the ionospheric condition with the dynasonde, the parameters of signal-to-noise ratio, echo frequency, echo polarization, echo location, and Doppler velocity are presented. Variations in the parameters demonstrate that during PMSE conditions, echoes of the dynasonde are mainly attributed by reflection of many small irregularities within the observed ionospheric volume.

Vertical phase and group velocities of ionospheric gravity waves derived from ionograms

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A procedure is developed to derive the vertical phase and group velocities of waves from measurements of ionogram. We apply the developed procedure to a sequence of ionograms recorded by the digisonde portable sounder in Taiwan and find numerous waves occurring in the ionosphere during the solar ellipse of 24 October 1995. A detailed analysis of an 87-minute period wave shows that the vertical phase velocities of the wave below and above the F1 ledge are about 100 m/s in the downward and upward directions, respectively. The associated group velocities below and above the ledge are found to be about 10 m/s in the downward and upward directions, respectively, which indicates that during the solar eclipse the wave source is near the F1-ledge.

AURORAL THERMOSPHERE HEATING AND ELECTRON DENSITY DEPLETION IN THE F-REGION AT HIGH- AND MID- LATITUDES DURING TWO INTENSE MAGNETIC STORMS

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With the help of combined EISCAT and ionosonde network data, a comprehensive analysis was made to investigate electron density depletion in the auroral F-region and ionospheric negative storm effects at mid-latitudes associated with auroral thermosphere heating during two intense magnetic storms. The storms occurred at spring equinox (min.Dst<-135nT) and near summer solstice (min.Dst<-145nT) in 1990. The time and height-integrated Joule heating during the storms over the EISCAT site was about 2100 J/m^2 for the former and about 4300 J/m^2 for the latter. The negative storm in June at latitudes of 38-63 N in the European sector showed two discrete patterns, related to two distinct periods of strong heating during the initial and main phase of the storm. The maximum of the negative phase appeared 6-7 hours later than the maximum auroral heating, while the depletion of Ne in the auroral upper F-region reached its maximum just about 10 minutes after the maximum Joule heating. For the March storm, mid-latitude F-region negative storm effects are seen at the European and the West-Asian sectors; while no such negative effects are found for the East-Asian sector in the northern hemisphere.

COUPLING BETWEEN TEMPORAL AND SPATIAL SCALES AND MODELING DISTURBANCES CAUSED BY EXTERNAL ELECTRIC FIELD IN THE LOWER IONOSPHERE

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Relations between characteristic time and space scales of disturbances in an ionospheric plasma are obtained in a matrix form. All processes can be classified as time, space and space-time ones, therefore the use of the matrix representation of relations between characteristic time and space scales permits essentially to simplify the construction and analysis of models for a wide class of phenomenon. A dynamic model of disturbances in the ionospheric *D* region caused by strong quasi-stationary atmospheric electric fields is obtained using both the matrix relationship between time and space scales and the method of multiple caling analysis. The author has been supported by UNTC Grant 471.

ON THE INVOLVMENT OF SCHUMANN RESONANCES IN HIGH LATITUDES PLASMA STRUCTURING

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Simultaneous measurements of electron density and ELF electric field by the AUREOL 3 satellite have allowed Cerisier et al. (1985) to point out the existence of medium scale density irregularities in the high-latitudes topside F region and to establish the role of the gradient drift instability in the plasma structuring. Detailed analyses of the same data show: first, that peaks in the power spectra of the electric field components are seen at the Schumann resonance frequencies, second that the harmonics are associated with positive electron density gradients, and third that the resonances are in quadratic interaction with a 5.85 Hz power peak present in the electron density fluctuations.

PRODUCTION OF METASTABLE HELIUM IN THE THERMOSPHERE BY HE+ RECOMBINATION

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Observations of the metastable helium emission, 1.0830μ, have been made at the optical facilites at the Millstone Hill Incoherent Scatter Radar site and the Arecibo Observatory over the last three years. The data indicate an increase of temperature with shadow height. Tempertures much greater than commonly ascribed to the near solar minimum thermosphere have been observed. This suggests the temperature of the emitting population is greater than the temperature expected of neutral helium, approaching the temperature of the helium ions.
This can be explained only if the recombination of ionized helium plays a larger role in the production of metastable helium in the thermosphere than current models indicate.
Data is presented from three different campaigns (two from Millstone and one from Arecibo) demonstrating the increase of temperature with shadow height. Metastable helium densities are derived from He+ densities from both Incoherent Scatter Radar observations and the FLIP and IRI90 models when radar data is unavailable. These calculations demostrate the plausibility of He+ recombination as a significant source of hot, metastable helium.

PERCOLATION MODEL OF F2 LAYER CRITICAL FREQUENCY.

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A model of an interaction process of a probing radioimpulse with irregular plasma near *F2* layer maximum has been created as a percolation transition. In it an electronic concentration distribution *N(r,t)* near critical frequency *fc* (a form, an orientation and dynamics of irregularities during an experiment) has been modeled. A condition of reflection *n=0* is determined for each radioimpulse spectrum frequency *S(f)*, as well as a lattice cell dimension, proportionate to wave length. A lattice cell is considered to be occupated, if *N (r, t)=No*, where *No* is an electron concentration at *n=0*. The presence of connecting claster is determined by renorm-group method. Frequency, corresponding to the first connecting claster occurrence for given *N(r,t)* is considered the layer critical frequency. The analysis *fc* from numerical experiment has shown the good agreement with earlier received experimental data. This model using allows also to receive the information about electronic concentration irregularities with the help of experimental registrations *fc*.

THE QUASI-TWO-DAY WAVE IN THE THERMOSPHERE: A STUDY USING THE TIME-GCM

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The quasi-two-day wave is a global-scale oscillation typically observed in the middle atmosphere horizontal wind and temperature fields near the solstices. Both ground and satellite based observations, of the quasi-two-day wave, indicate that the quasi-two-day wave is a westward propagating disturbance with a period near 48 hours and a zonal wave number of three. Theoretical results have indicated that the quasi two-day wave may be a manifestation of the (3,0) Rossby normal mode in a linearized, windless, isothermal atmosphere. Based on these theoretical results we have performed a numerical experiment using the NCAR Thermosphere-Ionosphere-Mesosphere-Electrodynamics general circulation model (TIME-GCM). The TIME-GCM is a three-dimensional self consistent first principles model with a domain spanning from 30 to 800 km. For the purpose of this experiment we have run two cases. In the first case the quasi-two-day wave was included at the lower boundary of the TIME-GCM (30 km) in the geopotential height field as the (3,0) Rossby normal mode. In the second "control" case the quasi-two-day wave was not included at the lower boundary. A comparison of the results for the two cases will be presented for the thermosphere with an emphasis on the latitudinal/height structure of the quasi-two-day wave.

PROPAGATION OF PLANETARY WAVES INTO THE THERMOSPHERE AND IONOSPHERE - A MODELLING STUDY

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Numerous measurements have found signatures of planetary waves in the ionospheric F-layer, while measurements in the neutral atmosphere often suggest such waves to propagate only to altitudes below around 200 km. A modelling study is presented which uses the 3-dimensional time-dependent Coupled Thermosphere-Ionosphere Model (CTIP) of University College London, Sheffield University and the Space Environment Center Boulder (Colorado). Mechanisms are analyzed by which planetary waves can propagate into the ionosphere. In particular, the importance of modulated tides is investigated.

NEW ELECTRON ENERGY TRANSFER AND COOLING RATES BY EXCITATION OF N_2 AND O_2

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The electron energy transfer and cooling rates by vibrational excitation of N_2 and O_2 have been calculated and fitted to new analytical expressions as functions of the electron temperature by use the revised vibrationally excited cross sections. These new analytical expressions available to the researcher for quick reference and accurate computer modeling with a minimum of calculations. The new O_2 (v) rates are up to a factor of 5-18 larger than those of Prasad and Furman (*J. Geophys. Res.*, **78**, 6701-6707,1973). The difference between the new electron cooling rate due to N_2(v) and those of Stubbe and Varnum (*Planet. Space Sci.* , **20**, 1121-1126,1972) is up to a factor of 1.7. We have shown that the vibrational levels v=1-4 (O_2) and v=1-7 (N_2) are enough to calculate the O_2 (v) and N_2 (v) electron cooling rates. Our results provide sufficient evidence to neglect the effects of the excitation of the $a^1\Delta_g$ and $b^1\Sigma_g^+$ electronic states of O_2 with thermal electrons on the calculation of the electron temperature. It is also shown that the currently accepted rate of electron energy loss associated with rotational transitions in O_2 must be decreased by a factor of 13 and electron energy loss associated with rotational transitions in N_2 must be multiplied by a factor of 1.255.

ANOMALOUS ELECTRON DENSITY EVENTS IN THE QUIET SUMMER IONOSPHERE AT SOLAR MINIMUM OVER MILLSTONE HILL

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This paper compares the observed behavior of the F region ionosphere over Millstone Hill with calculations of the IZMIRAN time-dependent mathematical model of the Earth's ionosphere and plasmasphere for solar minimum for the magnetically quiet period June 23-25, 1986, when anomalously low values of hmF2 (< 200 km) were observed (seen as a G condition on ionograms). The IZMIRAN model was unable to reproduce these anomalously ionospheric electron density altitude profile when unadjusted MSIS-86 model densities were used, or when the MSIS-86 N_2 and O_2 densities were increased by a factor of 2, or due to the effect of vibrationally excited NO^+ ions on electron densities (which is found to be negligible). We found that these low values of hmF2 exist in the ionosphere due to a decrease by a factor of 1.6 production rates of oxygen ions resulting from low values of atomic oxygen density. Large errors were found at times in electron and ion temperatures, and hmF2 data derived using the standard Millstone Hill ion composition model, due to the large percentage of molecular ions found above 180 km. Results show that determination of a G condition using incoherent scatter radar data is sensitive both to the true concentration of O^+ relative to the molecular ions, and to the ion composition model assumed in the data reduction process.

ELECTRON DENSITY SIGNATURES OF HIGH-LATITUDE PLASMA PROCESSES

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A chain of four satellite receivers at Ny-Ålesund, Longyearbyen, Bjørnøya and Tromsø is used to monitor radio signals from the former navigational satellite system on routine basis to provide tomographic images of the ionospheric electron density. The spatial distributions reveal ionospheric signatures of fundamental plasma processes, including magnetopause reconnection and auroral precipitation, and show the presence of features characteristic of the high-latitude ionosphere including the cusp, dayside trough and polar hole. Results are presented highlighting the unique ability of this technique to image the ionosphere over an extended latitudinal region, spanning from the auroral zone into the polar cap and covering the viewing area of the EISCAT and ESR incoherent scatter radar facilities. The observations are interpreted making use of high-latitude convection patterns for prevalent IMF conditions and measurements by radar, optical and other experimental techniques operated in the vicinity of Svalbard.

EVALUATION OF THE EFFECT OF THE NEUTRAL WINDS ON THE INNER MAGNETOSPHERIC CONVECTION WITH A MAGNETOSPHERE-THERMOSPHERE-IONOSPHERE-ELECTRODYMANICS GENERAL-CIRCULATION MODEL

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We coupled the Ionosphere-Magnetosphere Model of Peymirat and Fontaine (JGR, 11155, 1994) to the Thermosphere-Ionosphere-Electrodymanics General-Circulation Model of Richmond et al. (GRL, 601, 1992). This new model has the capability to calculate the three-dimensional structure of the thermosphere and the ionosphere, the two-dimensional inner magnetospheric plasma convection in the equatorial plane of the magnetosphere, and the couplings between these three regions. A dipole magnetic field is used in the magnetosphere. We ran the model for solar maximum conditions and moderate magnetic activity where the electric field is imposed in the polar cap but calculated everywhere else, to study the effect of the neutral winds on the electrodynamic couplings occuring at high latitudes. The neutral winds increase the meridional component and decrease the zonal component of the electric field, corresponding to an enhancement of the shielding effect by 10 %. The Region-2 field aligned currents present smaller modifications suggesting that the magnetosphere acts partly as a current generator. The results could be different if the polar cap electric potential was allowed to change due to the neutral winds.

VARIABILITY OF EQUATORIAL F-REGION VERTICAL PLASMA DRIFTS

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At low latitudes, ionospheric plasma drifts play an essential role on the distribution of ionization and the dynamics of the thermosphere. These plasma drifts exhibit large temporal and spatial variability. We use incoherent scatter radar observations from Jicamarca and Ion Drift Meter data from the AE-E satellite to study these variability of the equatorial vertical plasma drifts during geomagnetically quiet periods.
We will present initially a detailed study of the annual and solar cycle variations of the plasma drifts and a new empirical analytical model for their representation. We show that during daytime and low solar flux conditions the average Jicamarca spring and fall vertical drifts differ significantly. The development of a presunrise enhancement in the equatorial vertical drifts is found near June solstice and periods of medium solar flux but is absent during other times. We will also present the longitudinal, seasonal, and solar cycle variations of the equatorial vertical plasma drifts obtained from the AE-E satellite and compare them with radar results.
We show that day-to-day variability near the equator is most pronounced during the day and decreases with increasing solar flux. Near March equinox this variability is strongly enhanced.

INFLUENCE OF THE GLOBAL THUNDERSTORM ACTIVITY ON THE ELECTRIC FIELDS IN THE IONOSPHERE

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The large-scale electric fields exited by the world thunderstorms are calculated by means of the model of the spherically symmetrical atmosphere. Contrary to the models of the global atmospheric electric circuit with the equipotential electrosphere, here we have taken in account that on the ionospheric heights the field-aligned component of the exited electric field tends to zero because of the high conductivity of medium along the geomagnetic lines. The appearance of the regions of the large-scale spheric harmonics of potential with quasiconstant (on the altitude) amplitude is connected with this circumstance. This weakens the attenuation (with the altitude) of the global fields of the thunderstorm sources in the ionosphere which is not the equipotential surface for the atmospheric electric fields. Using the suitable upper boundary condition, we have investigated the possible non-equipotentiality of the ionosphere and we have estimated the electric fields penetrating into ionosphere from the bottom. In particular, it is shown that the horizontal components of the electric field can reach the magnitude about 1 mV/m in the ionosphere.

A NEW METHOD FOR ADVANCED FABRY-PEROT DATA PROCESSING

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The technique to process Fabry-Perot images in order to derive neutral wind velocities and neutral temperatures is not straight forward. The usual method applying a circular integration has the disadvantage that it is very sensitive to an exact determination of the center of the image. Using an incorrect center causes a broadening of the profile. While this is usually not too critical to velocity estimates, it leads to an overestimation of the temperature. A full 2-dimensional fit - although consuming more computer time - avoids this disadvantage, providing more accurate velocity and temperature estimates. In addition it automatically takes the flat-field and the dark-image corrections into account. The method is explained and examples are discussed.

NEW NEAR-IR EXPERIMENTAL TECHNIQUES TO DETERMINE THERMOSPHERIC COMPOSITION AND DYNAMICS

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New capabilities to remotely sense atomic oxygen density, metastable helium density, and atomic oxygen temperature and winds above the F2 ionospheric peak are developed. These ground-based observational techniques are all based upon Fabry-Perot Spectrometer measurements.

Atomic oxygen densities, temperatures, and winds are measured above the F2 peak using Doppler profiles of the 844.6 nm emission, spectrally isolated from OH contamination using a resolving power of 400,000. Metastable helium densities and temperatures are measured using doppler profiles of the 1083.0 nm emission from the twilight airglow. These measurements feature the use of a germanium detector, and suggest that recombination of He+ is a significant source of the 1083.0 nm emission.

In addition, we demonstrate a novel new Fabry-Perot design that permits fast, robust, lightweight space-based application of these techniques. The new Fabry-Perot design employs nematic liquid crystals as the refractive medium of a system that is scanned entirely electronically. Rapid scanning and tunability of the new liquid-crystal Fabry-Perot is demonstrated by display of the highly portable instrument.

STUDY OF HF INDUCED PLASMA WAVE DISSIPATION IN THE MODIFIED IONOSPHERE USING STIMULATED ELECTROMAGNETIC EMISSION.

E.N. Sergeev, V.L. Frolov (Radiophysical Research Institute, Russia)

A new method to monitor the dissipation processes of HF plasma waves induced by a powerful pump wave (PW) in the ionospheric F-region is presented. The measurements with high time resolution (~ 0.3 ms) have been performed at the SURA heating facility (N. Novgorod, Russia), using the decay of the stimulated electromagnetic emission (SEE) generated by HF plasma wave conversion.
Low duty pulse schemes of the PW radiation with $\tau_{on} \sim 15$–200 ms $<< \tau_{off} \sim$ 1–10 s are used to investigate the evolution of the Langmuir plasma turbulence, generated near the reflection level of the PW. It has been found that the Langmuir plasma wave damping rate ν, defined from the SEE intensity e-folding decay time $\tau_d = \nu^{-1}$, is close to the collisional damping rate $\nu_i \simeq 150 - 300$ Hz for ERP $P < P^*$ ($P^*(\tau_{on}) \simeq 4$–18 MW ERP, taking into account D-region absorption), but increases by 4 - 6 times to the collisionless damping rate with increase of the pulse duration and the pump power as well as under diurnal conditions in comparison with nighttime conditions.
Quasi-continuous heating with $\tau_{on} = 180$ ms $>> \tau_{off} = 20$ ms is used to investigate the evolution of the Upper Hybrid plasma turbulence and artificial small scale irregularities (ASSI). It has been found that the maximal Upper Hybrid plasma wave damping rate, $\nu \simeq 700 - 1000$ Hz, is observed for the steady state of ASSI after long heating and weakly depends on the pump power for $P > 5$–8 MW ERP, but slightly decreases in 1.5 - 2 times when going from diurnal to night conditions. The minimal damping rate, closed to collision frequency (ν_e), is observed at the final stage of ASSI relaxation after a change from quasi-continuous heating to the low duty pulse scheme. Besides, a two step decay process of the Upper Hybrid plasma waves, with a rapid (ν) and a slow (ν_i) damping rate, are observed at the development and relaxation stages of ASSI.
The data presented are compared with ISR observations of the ionospheric Langmuir turbulence over Arecibo. To explain the dissipation process of the HF plasma turbulences, the mechanisms of the plasma wave energy transfer over the spectrum and its spatial distribution in the perturbed volume, as well as collisionless damping by the accelerated suprathermal electrons and the strong turbulence generation are discussed.

STUDY OF *FAI* PROPERTIES IN THE MODIFIED IONOSPHERIC F-REGION BY MEANS OF STIMULATED ELECTROMAGNETIC EMISSION IN ADDITIONAL HEATING EXPERIMENTS.

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An overview is presented of the results concerning the influence of field aligned irregularities (FAI) of the ionospheric plasma density, generated by additional heating using a powerful pump wave (PW) with $P \simeq 60$ MW ERP, on the stimulated electromagnetic emissions (SEE) generated by the continuous or pulsed diagnostic wave (DW) radiation with a small average power $\overline{P} < 10$ MW ERP and frequency offsets in the range $|\delta f^{\pm}| = |f_{pw} - f_{dw}| = 0 - 1000$ kHz.
An essential dependence of the temporal evolution of the SEE intensity, induced by the additional heating on the frequency offset $\delta f^{\pm}$ as well as on the PW frequency value, especially in the vicinity of the electron cyclotron frequency harmonics nf_{ce}, is found. In particular, a drop in the influence of the additional heating on the SEE temporal evolution for $f_{pw} \simeq 4f_{ce}$ is observed.
Variations obtained for the growth and relaxation time and the overshoot value of the additional SEE intensity, coupled with an elaborated empirical model of the FAI spectrum evolution and a theoretical model of the SEE generation, allow to use the SEE experimental data sets to determine the strength and the form of the FAI spectrum at different altitudes of the perturbed ionospheric volume.
The conclusion about the increase of the integral spectral strength of FAI with $l_\perp < \lambda_{pw}$, and especially for the scales $l_\perp \simeq 3 - 10$ m, with decreasing values of $|\delta f^{\pm}|$ less than 200 kHz, and f_{pw} below 5.2 MHz, as well as for $f_{pw} > 4f_{ce}$ in comparison with the opposite case $f_{pw} < 4f_{ce}$ (5 kHz $< |f_{pw} - 4f_{ce}| <$ 40 - 60 kHz), is confirmed.

DEPENDENCE OF THE FREQUENCY OFFSET OF STIMULATED ELECTROMAGNETIC EMISSION MAXIMA ON PUMP PARAMETERS.

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The results of precision measurements of the position of the main maxima relative to the pump wave (PW) frequency f_{pw} in stimulated electromagnetic emission (SEE) spectra are presented. The downshifted maximum (DM), with $\Delta f_{DM} = f_{DM} - f_{pw} = -(9...16)$ kHz, is the main feature of the SEE spectrum, and the dependence of the DM offset on the PW frequency, such as $\Delta f_{DM} \propto f_{pw}$, is observed [Stubbe et al., JGR, 1984]. The broad upshifted maximum (BUM) is the main feature of the SEE spectrum in measurements above the electron cyclotron harmonics $f_{pw} > nf_{ce}$, and a dependence of the BUM offset on the PW frequency close to $\Delta f_{BUM} \simeq f_{pw} - nf_{ce}$ is observed [Leyser et al., PRL, 1989].
In our measurements, a decrease of the value of Δf_{DM} by 1 - 1.5 kHz and of Δf_{BUM} by 5 kHz is found for fixed f_{pw} in the center of the modified ionospheric volume with an increase of the pump power, as well as with an increase of the duration of heating and the development of an overshoot of the SEE intensity. The effect of the DM offset is also observed in the spectrum of a weak PW (with frequency f_{pw_1} and power $P \simeq 2 - 4$ MW ERP) after the turn-on of an additional powerful PW (with power $P \simeq 60$ MW ERP and frequency f_{pw_2} obeying $|f_{pw_1} - f_{pw_2}| > 150$ kHz). The opposite, an increase of the value of Δf_{DM}, is observed for a period of ~ 30 - 60 s after the turn-off of the additional PW when the artificial field aligned perturbations (FAP) of the electron density and temperature, generated by additional heating, are relaxed.
The results obtained allow to associate the DM and BUM offset with a change of the FAP strength determining, in particular, the anomalous absorption and the spatial position of the SEE generation range in the vicinity of the upper hybrid resonance level.

CRITICAL FREQUNCY foF2 VARIATIONS AT EQUATOR

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The daytime behaviour of critical frequency foF2 at equatorial latitudes is investigated for period 1968-1984 from a complex point of view. Variations fof2 are compared with F-region zonal electric field, horizontal component of the magnetic field and interplanetary medium data. The interaction of the magnetospheric and ionospheric current system has been shown to be the controlling factor of fot2 variations.The "bite-out" changes during quiet days are analysed.

THE IMPEDANCE AND LANGMUIR PROBES IN THE DEOS CAMPAIGN

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In the DEOS campaign three sounding rockets will be launched from southern India to study the diurnal variation of the dynamics of the E- and F-layers at the edge of the equatorial electrojet. Langmuir and Impedance probes will be employed to measure plasma densities, temperatures and density fluctuations. The new Impedance probe uses digital frequency synthesis and allows for a good spatial resolution (130 m) together with high accuracy (1.5%) due to the fast sweep time of the instrument. The two Langmuir probes will employ a temperature and a fluctuation mode. By this approach plasma densities and temperatures measured with the Langmuir probe in temperature mode have the same spatial and temporal resolution as densities measured by the Impedance probe, while density fluctuations up to 1.5 kHz can be detected by the Langmuir probe in fluctuation mode. First results from the campaign to be performed in March 1998 will be presented. A comparision of density fluctuations measured by the Langmuir probes and density gradients determined from the Impedane probes gives first hints on gradient driven instabilities.

AN ATTEMPT TO INTERPRET NON-MAXWELLIAN SPECTRA FROM THE EISCAT SVALBARD RADAR (ESR)

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A persistent feature of the data from the new EISCAT Svalbard Radar (ESR) is the reccurent occurrence of spectra differing significantly from those corresponding to a thermal ion and electron populations. Spectra showing distortions of one or both shoulders are frequently observed, as well as triple humped spectral forms, even for field-aligned observations. The ESR spectra do not exhibit the strong enhancement previously observed in anomalous spectra at other incoherent scatter radars. They rather present a different distribution of power within the spectra compared to a Maxwellian. The ESR spectra vary rapidly both in time and in altitude. The instability mechanisms proposed to explain the features observed by the mainland radars are not able to explain those observed by the ESR. Most of the spectra can be interpreted successfully in terms of mixtures of several ion populations, with different drift velocities and/or temperatures, within the scattering volume. We attempt to produce simulated distorted ESR spectra, by means of different ion populations. Proton and heavier ion precipitation over Svalbard might, through different collision processes, create secondary particle distributions matching the phase velocity of the ion acoustic wave observed by the ESR.

FIRST RESULTS OF LOW-LATITUDE ROCKET PROJECT DEOS: DYNAMICS OF THE EQUATORIAL IONOSPHERE OVER SHAR

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The DEOS rocket campaign will be performed during equinoctial conditions in March 1998 from the low-latitude station of Sriharicota Range , India. Results are presented from three successive rocket launches during evening, night and daytime conditions. This sequence determines prereversal current enhancement, Spread-F and Sporadic-E effects, which are the primary targets of the investigation. Spread-F conditions require prediction by an airglow technique during afternoon hours in order to follow this sequence. The in-situ instruments provide local measurements of standard plasma parameters on various scale sizes. Radio beacon transmitter signals onboard are received by four different ground stations. The related TEC-measurements provide horizontal information of ionospheric plasma patterns. A net of ground-based facilities will be operated during the launch campaign to guide the rocket measurements. The latitudinal extent of electrojet and Sq current system are identified by a chain of ground-based magnetometers. Ionosondes, distributed over four locations, measure the temporal and spatial evolution of Spread-F and Sporadic-E features and provide a link to the TEC distribution. An ionosonde at SHAR verifies the uplifting of the F-layer during presunset conditions.

METHODICAL ASPECTS OF ROCKET MEASUREMENTS OF ELECTRIC FIELD AND ELECTRICAL CONDUCTIVITY IN THE LOWER IONOSPHERE AND THE ELECTROSPHERE

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Industrially released equipment for the ***in-situ*** measurements of electric field and electrical conductivity in the lower ionosphere and the electrosphere does not exist. Each separate group of researchers is forced to design its own variant of instrument, measuring properties of which, as a rule, are dependent both on the concrete configuration of the rocket payload and the flight regime of the rocket being used. At the same time, practically no publication concerned these investigations reflects the main sources of errors and presents their relative contribution in the results of measurements. Therefore, it is difficult to compare the results of separate investigations and to detect common regularities. In this paper methodical and metrological aspects of such investigations are considered, hardware and exterior sources of errors are estimated. Some of previously unpublished results of strato-mesospheric measurements of electric field strength and electrical conductivity by means of «mother - daughter» rocket system are given.

DISTRIBUTION OF MAJOR IONS IN THE OUTER IONOSPHERE FOR THE MAXIMUM OF THE 22nd SOLAR CYCLE (LOW AND MIDDLE LATITUDES)

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Ion composition data from the Bennett ion mass spectrometer onboard Intercosmos 24 satellite (perigee ~550 km, apogee ~2500 km) have been used to study altitudinal and latitudinal distributions of three major ions - O^+, H^+, and He^+ during the period 1989 - 1991 (maximum of the 22nd solar cycle) in low and middle latitudes. Analysis has been done considering seasons, local time and geomagnetic activity. Experimental profiles are compared with profiles from numerical models. The role of He^+ in the upper transition height (O^+ to light ions) is discussed, especially in the cases of the He^+ dominance.

CONTRIBUTIONS TO MODELLING OF COUPLING BETWEEN IONOSPEHERE AND INTERPLANETARY MAGNETIC FIELD

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In our preceding papers (XVIII Egs.Gen.Ass 1993-XXII Gen.Ass.1997;24th ICRC Rome 1996;25th URSI Gen.Ass.1996) we analised the different aspects of coupling among atmosphere-ionosphere-interplanetary magnetic field via solar-activity,with regard special to ionospheric disturbances.In case of ionosphere-interplanetary magnetic field interaction we are coming (with other authors) in basis of ground and satellit observations to the conclusion that the lower ionosphere in domain of long and very long radiowaves responds with a delay of 7-9 days to the sudden changes of interplanetary magnetic field,as to sources of the geomagnetic storms,respectively.According to the fact that the changes in the (lower) ionosphere follow at all times with a considerable delay the changes of interplanetary magnetic field we consider that this ineracting system we can model with a RL ,as rezistor-inductor circuit.For this reason during increasing phase of magnetic storm we can describe the electric field strenght with formula : $E = E_0 (1 - \exp(-t/T))$ and in his decreasing phase we have $E=E_0 \exp(-t/T)$, where $T = L/R$ it is the time-constant of circuit,R being the rezistivity and L the inductivity of circuit.In that case if the variation of temperature of interacting system is known ,we can estimate the value of R and in knowledge of time-constant we can deduce L.

MODIFICATION OF IONOSPHERIC CHAPMAN FUNCTION TAKING INTO ACCOUNT OBLATENESS OF PLANETS

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Theoretical expression for modified Chapman function *Che* with account of oblateness of planets is derived. The planets are represented as oblate ellipsoids of revolution. *Che* depends not only on the solar zenith angle χ and the altitude of watchpoint (as *Ch* is by spherical planet), but also on the solar declination and on the latitude of spot of surface of ellipsoid, which normal gets through the watchpoint. This causes latitudinal and seasonal effects on the electron production rate function and thus influences the whole theory for the formation of the ionosphere. These effects are due to the difference towards the spherical form of the planet. A software package for calculation of *Che* is developed. *Che* is tabulated for the Earth at heights 50-1000 km, i.e. the *D*, *E* and *F*-regions. More essential difference of *Che* from *Ch* are observed at $\chi \sim 97\text{-}100°$, i.e. in the sunrise-sunset periods. For Saturn (greatest oblateness 0.104 from the planets in the Solar System) this difference is 50%.

SMALL-SCALE STRUCTURES of QUIET DAY F2 LAYER IONISATION DENSITY at VERY LOW MAGNETIC LATITUDES

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From early times, regular F2 layer measurements at the magnetic equator have evidenced additional daytime fluctuations in the body of the F2 layer. These cannot be attributed to diurnal mesoscale fountain motions, and they seem to differ profoundly from one solar Cycle to the next. **i)** In Cycle 19 Jicamarca Incoherent scatter soundings revealed periodic quasi-standing waves of about 12 minute period; 1965 and 1966 airborne ionograms along the Central African meridian yielded similar periodic structures at subtropical and tropical dip latitudes. **ii)** In Cycle 20, isolated strata were seen to generally rise from F1 to peak F2 levels at Sahr (Chad). **iii)** In Cycle 22, larger recurrent structures abound in West Africa IEEY, 1992-1994) inside the near-equatorial zone of +5°> mag. latitude> 5° which seem only occasionally related to auroral fronts .Pending fine-scale modeling tests of these solar cycle discrepancies between structures, we investigate their local and external sources, as regimes of the equatorial electrojet altitude shells differently dominated by wave turbulent, electric field or electric current, and as spatial variations of the sub-solar pressure bulge boundaries, in their dependence on auroral electric field Acoustic Gravity Wave forcing.

ATOMIC OXYGEN FORBIDDEN LINES MODELIZED DURING A WINDII-EISCAT COORDINATED MEASUREMENTS

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The red and green lines of the atomic oxygen have been studied for more than 30 years, and their modelization is difficult. It requieres in particular the knowledge of the EUV solar flux, the photoelectrons flux, neutral, ion and electron densities and temperatures, and chemical reactions that occur in the ionosphere.

The aim of this study is to model the OI dayglow ($^3P - ^1D$,λ 630 nm and $^1D - ^1S$,λ 558 nm) with the TRANSCAR model. This model solves the fluid equations for the ions and the electrons and the kinetic transport equation for the photoelectrons. This code already showed its capability to describe the ionosphere above 90 km.

The emission rates are computed versus the altitude during a coordinated WINDII (on board of UARS)-EISCAT experiment. The neutral densities given by the MSIS model are set to adjust electron densities and temperatures measured by the radar and given as outputs of the TRANSCAR model. Several sources and sinks of both exited states of the atomic oxygen are reviewed and discussed.

ST4 Open session on the magnetosphere

Convener: Rycroft, M.J.
Co-Convener: Sandahl, I.

A MODEL OF DISTURBED MAGNETOSPHERE

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Previous paraboloid magnetospheric model was presented in a new form allowing to describe and analyze the magnetospheric disturbances. Tail lobe magnetic flux value Fpc was introduced as input parameter of magnetospheric model. Model key parameters and ground state of the magnetosphere were determined. The presure balance in the subsolar points limited the values of these magnetospheric model parameters. The influence of interplanetary magnetic field (IMF) on the magnetospheric magnetic field was studied by examination of the position and size of the magnetopause merging area. The influence of the IMF, field-aligned and tail currents on the the location and shape of the open field line bundle attached to the polar cap was studied. Such bundle exist not only as result of IMF and magnetospheric field reconnection at the magnetopause but as result of tail lobe field lines connection with IMF at the distant tail cross-section. Contrary to popular opinion, it was found that the area of polar cap is strongly controlled by the tail current, but only weakly by the IMF. The tail current contribution in Dst during magnetic storm has the same valie as ring current contribution. A case study strongly support the simulation results.

MAGNETOSHEATH'S MAGNETIC FIELD AND MAGNETOPAUSE STRUCTURE FOR HIGH MAGNETIC SHEAR

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The supersonic solar wind - Earth's magnetosphere coupling plays the main role in the solar wind energy, momentum and mass input into the magnetosphere. The new dynamic model of magnetic field in coupled solar wind - magnetosheath - magnetosphere system is considered. Magnetosphere is presented by the paraboloid model. The MHD equations in the magnetosheath, where the compressible ohmic conducting solar wind plasma flow past the magnetosphere, are solved as a singularly perturbed system with two independent small parameters, which are inversely proportional to Mach-Alfven and magnetic Reynolds numbers.

The analytical solution for plasma flow and magnetic field was obtained. The magnetic field near the magnetopause is formed due to mutual diffusion of the magnetospheric magnetic field in the solar wind and IMF into the magnetosphere. For the typical magnetosheath conditions, magnetopause thickness is about of 100 times less than stand-off distance. The proposed model allows to determine the reconnection efficiency, potential difference accross the polar cap, energy input rate into the magnetosphere by IMF and solar wind parameters: velocity, density, conductivity. The calculated solar wind plasma and magnetic field parameters in the magnetosheath are compared with average variations of those obtained by AMPTE/IRM satellite for high magnetic shear.

EQUILIBRIUM OF THE MAGNETOSPHERE AND TAIL CURRENT DYNAMICS

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The problem of magnetospheric equilibrium is discussed based on paraboloid model of the magnetosphere. The equilibrium condition of the magnetosphere under various magnetospheric configurations was described. The critical values of model's parameters which correspond to the transition of the magnetospheric system to the metastable state were determined. It was shown that the magnetospheric dynamic strongly depends on the distance to the subsolar point and to the inner edge of the tail current sheet. The processes accompanied by increasing of these distances lead to metastable configuration. As an example the IMF triggering of substorm break up was investigated. The northward turning of IMF cause the increasing of the magnetospheric space scale and as consequence the increasing of both mentioned above distances. The possibility of the substorm break up increases. An influence of the field-aligned currents on this process was discussed. At the growth phase when the intensity of field-aligned currents increases they stabilize the magnetospheric configuration. After turning IMF northward this stabilization factor disapeares and the possibility of the substorm break up increases. On the basis of these statments the hypothetical scenario of the substorm was constructed. Model results tested by the case study.

CHAOS IN PLASMA SHEET PARTICLE MOTION AND ITS CONSEQUENCES

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The results of experimental investigations of the plasma sheet electron motion on base of the Intercosmos-Bulgaria-1300 data are summarized. Auroral electron flux fluctuations in fixed energy channels are analyzed. It is shown that fluctuation spectra have the character corresponding to stochastic electron motion. The dependence of auroral electron temperature from the coordinate along the satellite trajectory is investigated. Electron acceleration by field-aligned electrostatic potential drops is taken into account. It is shown that electron temperature in the magnetically quiet conditions has no significant latitude dependence. The results of experimental data analysis are interpreted as the proof of stochastic character of plasma sheet electron motion. High amplitude electric field fluctuations was selected as the source of electron motion stochastization. Electron motion in crossed homogeneous magnetic field and electric field with sinusoidal dependence along one coordinate and finite homogeneous component along another is analyzed. Using the of Lyapunov exponent it is shown that particle motion became stochastic when particle Larmor radius is comparable with electric field nonhomogeneity scale. Stochastic character of electron motion limits the applicability of substorm theories postulating magnetized character of electron motion and its destruction as the cause of reconnection beginning and substorm expansion.

QUIET TIME PLASMA PRESSURE PROFILE AND ITS CONNECTION WITH ADIABATIC PLASMA TRANSPORT

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One of the main plasma trap characteristic is the plasma pressure distribution in the trap. Radial plasma pressure gradients in the conditions of magnetostatic equilibrium supports azimuthal currents in the trap. Plasma pressure gradients along magnetic flux tube volume isosurfaces creates field-aligned currents. Pressure distribution instability may be the cause of electric fields generation. Magnetospheric trapped radiation is the main source of plasma pressure in the inner magnetosphere regions. During magnetospheric storms and substorms such distribution is distorted due to inner magnetosphere hot plasma injections. Dst magnetic field variation is produced by the difference of disturbed and quite time ring current. So for comparison satellite particle measurements with near Earth magnetic field measurements it is necessary to know quite time plasma pressure profile. Such profile can be obtained on the base of existing models of trapped radiation. Calculations of plasma pressure profile based on the model AP8 are presented. Calculated profile is compared with Cosmos-900, Molnia-1 and AMPTE/CCE data. It is shown that the results of calculations are in a rather good agreement with experimental data. To analyze the mechanisms of quite time pressure profile formation radial diffusion model is used. It is shown that adiabatic diffusion processes can explain quite time plasma pressure profile.

THREE-DIMENSIONAL TURBULENT PLASMA SHEET MODEL

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Possible role of the medium-scale turbulent transport in plasma sheet dynamics is analyzed in diffusion approximation. The turbulent diffusion may compensate the compressive action of the dawn-dask electric field and support the plasma sheet stability. This model explains the plasma sheet thinning without compression during substorm. The existence of the developed turbulence is supported by auroral and plasma sheet electric field measurements: amplitudes of observed electric field fluctuations are an orders of magnitude higher than the dawn-dusk electric field amplitude. Medium scale electric field fluctuating vortexes may give the main contribution to transport coefficients. The developed theory of turbulent plasma sheet formation permits to determine plasma pressure – magnetic field vector potential dependence. to solve Grad-Shafranov problem and to restore magnetic field line configuration if plasma pressure distribution on the tail axis is known. The theory was generalized on the three-dimensional case. In accordance with experimental observations it was suggested that plasma temperature does not change across the plasma sheet. Tsyganenko magnetic field models was used for modeling plasma sheet large-scale electrostatic potential distribution in the tail on the basis of ionospheric potential. Three-dimensional distribution of plasma concentration for different IMF orientations was obtained. During $B_z^{IMF} < 0$ model plasma sheet has concave structure. During $B_z^{IMF} > 0$ bulge structure in the center of the sheet was formed. The developed model may explain plasma sheet bifurcation and theta-aurora formation during northern direction on the IMF.

Geomagnetic and Solar Wind Control of Magnetospheric Mapping

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The empirical magnetic field model by Ostapenko and Maltsev [J. Geophys. Res., 1997, 102, 17467] has been used for mapping at the distances of 3-10 RE. The model depends on the Dst and Kp-indices, solar wind pressure, IMF vertical component and tilt angle of the Earth dipole. This model is more precise than the other ones. Position of the field line footpoints is expressed in terms of the five above-mentioned parameters by approximation formulas. Coordinates of the field line footpoints are mapped to the equatorial plane. A lot of maps for various situations are obtained and compared. It is shown that these projections are controlled mainly by the Dst index at all longitudinal sectors. The Kp index influences the mapping in the nightside sector predominantly, whereas the solar wind pressure has the strongest effect at the dayside. The effect of the IMF appeared to be insignificant.

PLASMA PRESSURE GRADIENTS AS THE MAIN CAUSE OF MAGNETOSPHERE DYNAMICS

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The most natural way to explain in the first approximation any plasma trap dynamic is to analyze pressure distribution in the trap and its stability. For the case of magnetospheric trap for a long period of time information about plasma pressure distribution was very limited. So the point of view based on the suggestion of secondary role of such gradients and explanation of global magnetospheric dynamics by MHD generator action or viscous interactions in the boundary layers became dominant. The theories of solar wind source of dawn-dusk electric field meet with real difficulties when it became clear that maximal dawn-dusk potential drop is projected on the inner magnetosphere regions. In such a case it was natural to explain dawn-dusk electric field formation as the result of ionospheric dynamo layer Region 1 currents closing and connect Region 1 currents generation with the existence of plasma pressure gradients along magnetic flux tube volume isolines with pressure minima near midnight. It became possible to show that such gradient existence is the natural cause of magnetospheric trap geometry. So noncontradictory way to explain magnetospheric dynamics by inner magnetosphere processes arise. The main theory aspects are discussed.The theory contain the possibility to explain IMF control of dawn-dusk electric field dye to IMF control of magnetospheric currents. Inner magnetosphere currents changes produce magnetic flux redistribution between daytime and nighttime parts of magnetosphere and corresponding magnetopause motion. Many aspects of magnetosphere substorm dynamics are also possible to explain using the developed approach.

A STUDY OF PARTICLE BOUNDARIES DURING A SOLAR ELECTRON EVENT

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The relationship between different particle boundaries observed by NOAA-6 and TIROS-N polar low-altitude spacecraft is examined and compared with the solar electron plateau boundary (SBe) during a 5-day long solar electron event on September 15-20, 1979 including both relatively quiet intervals and a moderate magnetic storm on September 18. Observational arguments and comparison with predictions based on magnetospheric magnetic field models are presented to argue that SBe boundaries for 100 keV electrons (except for a narrow noon sector) are located deep inside of closed field lines of the plasma sheet and correspond to isotropic (i.e. precipitation) boundary of energetic electrons controlled by their non-adiabatic scattering in the equatorial current sheet. We investigate the relative locations of different particle boundaries as a function of Magnetic Local Time and discuss their physical interpretation.

A GROUND FACILITY FOR HIGH-LATITUDE MAGNETOSPHERIC SOUNDING

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During many years there were observations of echo-signals in different radiophysical experiments. One of the reasons of echo phenomena can be propagation of a signal along a magnetic line to the conjugate hemisphere and back to the transmitter. The experimental evidences of such a mechanism were given for the middle latitudes. In the Geophysical Observatory Loparskaya (LOP, φ=68.25^{0}N, λ=33.08^{0}E; Φ=64.52^0, Λ=113.9^0, L=5.2) a ground facility for observations of this kind of radioechoes in the high-latitude region has been constructed. It is a modified ionosonde with additional equipments which permit to investigate a chosen range of time delay. The first experiments have shown the possibility of the facility to be used for investigation of radioechoes.

A RADIATION BELT MODEL BASED ON CONVECTION-DIFFUSION THEORY INCLUDING A TIME DEPENDENT MAGNETIC FIELD

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A first physical Salammbô 4D model (latitude, longitude, radial distance and energy) has shown the importance of electric fields during the dipolarization phase [Bourdarie et al., "Electron and proton radiation belt dynamics simulations during storm periods. A new asymetric convective-diffusive model", J. Geophys. Res., 102, 17541, 1997]. But during the substorm growth phase, the magnetic time variations are prominent in the particle dynamics. So in the Salammbô 4D model a time dependent magnetic field has been added including day-side compression (Mead 64), field line stretching on the night-side (Williams 65) and a ring-current contribution (Tsyganenko 82). Here first results of this convection-diffusion model are presented for equatorial protons during a typical substorm. Effects on geostationnary orbit and GTO will be discussed.

ACCELERATION OF OXYGEN IONS AT THE EARTH'S MANTLE

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It is pointed out that oxygen ions can be accelerated near tangential discontinuity in the inner boundary of the mantle if they are scattered on the plasma micropulsations. The transport equation for energetic particles in the shearing flows is used. Energetic spectrums and fluxes of oxygen ions are given. This version explains why energetic oxygen ions tend to exist in the mantle region and their fluxes and energy are enhanced during geomagnetic activity as it is observed by the "PROGNOZ-7" and "GEOTAIL" satellites.

THE RESPONSE OF THE GLOBAL MAGNETOSPHERE-IONOSPHERE SYSTEM TO CHANGING IMF CONDITIONS: RESULTS FROM A 3D MULTISCALE SIMULATION

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The Michigan Global Magnetosphere Model is a recently developed three-dimensional solution adaptive code which solves the equations of ideal magnetohydrodynamics with our MAUS-MHD method (Multiscale Adaptive Upwind Scheme for MHD). The code is implemented for massively parallel computers and runs considerably faster than real time on a Cray T3E with 512 processors. The model is applied to simulations in which the global magnetospheric configuration changes in response to sudden rotations of the interplanetary megnetic field. Particular attention is paid to the temporal evolution of the magnetotail, the motion of the X-point, the evolution of reconnection geometries, and the changes in the ionospheric potential and convection patterns.

AMPTE/IRM OBSERVATIONS OF MAGNETIC FIELD ROTATION AT THE DAYSIDE MAGNETOPAUSE

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A study has been made of the magnetic field rotation observed during AMPTE/IRM crossings of the dayside magnetopause. These observations are compared with the predictions of a kinetic model of the tangential discontinuity (TD) magnetopause. Our main findings are: (a) the dominant presence of large positive magnetic field rotations in dawnside crossings north of the dawnside equator, (b) the observation of both rotation senses near the stagnation point and at the duskside, and (c) the rare occurrence and questionable TD nature of low magnetic shear dawnside crossings.

IMAGING OF BOUNDARIES IN MAGNETOSPHERE

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Imaging of large-scale structures in space plasma is a new exciting opportunity to study solar-terrestrial interaction. Remote electromagnetic (EM) sounding seems to be the unique method that can allow to investigate the structure and dynamics of such near - Earth formations as bow shock, magnetopause, plasmasphere and other magnetospheric boundaries. As an example the feasibility of Earth's bow shock EM sounding from outer space is discussed. Since the electron plasma density of solar wind and bow shock is within the limits of 1-500 electrons per cm^3, so for reconstruction of electron density profiles sounder must operate in the frequency band about 9-200 kHz, i.e. practically in very low frequency (VLF) range. For obtaining the information from large bow shock areas spacecraft has to be located at a distance not less than 25-30 Earth radii from ramp. Necessity to generate EM waves in VLF range and large distance between spacecraft and target lead to considerable technical difficulties for realization of EM sounding. The developed theory of operation of VLF sounder in rarefied plasma and detailed calculations of hardware implementation allowed to propose the system which may measure the coordinates, electron densities and velocities of sounded boundaries movement. The average transmitter active power required about 20 W only at maximal antenna length about 3 km and weight about 100 kg.

STRUCTURE OF THE MAGNETOSPHERIC MAGNETIC FIELD DURING MAGNETIC STORMS

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Complex study of large-scale magnetospheric current contributions to observational *Dst*-variation have been carried. In our analyses we used ground-based magnetometers data during 4 magnetic storms (Jan 27-30, 1985; Nov 23-27, 1986; Jan 14-16, 1988; May 06-08, 1988) and the paraboloid model of the magnetospheric magnetic field [Alexeev et al., *J.Geophys.Res.*, 101, p.7737, 1996] as well as the model of Maltsev [Maltsev et al., *J.Geophys.Res.*, 101, p.7697, 1996]. The input parameters for our study were the solar wind plasma parameters and north-southward IMF B_z); DMSP 6,7,8,9 spacecraft measurements of the location of various auroral particles precipitation boundaries; the AMPTE/CCE measurements of the total energy of ring current ions with energy of 1.5-300 kev/q. We have obtained the contributions of different magnetospheric current systems to *Dst*-variation such as the current on the magnetopause DCF, ring current DR, and geotail current DT. We have found a good agreement between observed and model magnetic fields during the main phase of the storms for both models. The paraboloid model allows to separate disturbances caused by various current systems. Such separation have shown that values of DT and DCF are comparable with DR during the main phase of the storms. During recovery phase effect DR predominates.

ON ENERGETIC ELECTRON SOURCES ON LOW L-SHELLS FROM SATELLITE DATA.

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Differential energy spectra of electrons E_e~0.3-2.0 Mev are considered on low L~1.2-1.7 inside the Earth's magnetosphere to calculate the electron distribution function. The data were obtained by two similar semiconductor spectrometers onboard "Intercosmos-19" (year 1979 - maximum of solar activity) and "Cosmos-1686" (year 1986 - minimum of solar activity). The calculated distribution function was used to estimate the electron's source time value corresponding to the definite radial diffusion coefficients and loss term (pitch-angle scattering and energy loss by Coulomb interaction, wave-particle interaction) for the inner radiation belt electrons during maximum and minimum of solar activity. The possible sources are considered taking into account the obtained time characteristic.

ABOUT PHASE SPACE OCCUPIED BY SYNCHRONOUS ELECTRONS UNDER THE EXTENDED SECOND-ORDER GYRORESONANCE INTERACTION WITH WHISTLER

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It is considered the nonlinear cyclotron resonance interaction of energetic electrons with ducted finite amplitude whistler of variable frequency propagating along the inhomogeneous magnetic field in the case of extended second-order resonance interaction and the variable wave frequency. The most strong interaction takes place for the so-called synchronous particles when the resonance is a global one on its spatial scale. The dispersion of synchronous electrons on the parallel velocity, the perpendicular one and the relative phase angle is studied for the different value of the synchronous phase corresponding both cases : the wave growth and its damping. It is shown that under some conditions the group of synchronous elecctrones can be the numerous enough to cause the significant effect on the wave amplitude dynamics. The possible application of results obtained to the magnetospheric conditions is discussed.
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Grazing Incidence Neutral Atom (GINA) Surface Conversion for the New Generation of Energetic Neutral Atom Imagers in Remote Sensing of the Magnetosphere

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Neutral atom imaging of magnetospheric ions is now possible over a broad range of energies from a few eV to more than a few hundred keV. For detection, energetic neutral atoms are converted to ions in one of two ways: (1) foil conversion-passage of the neutral atom through a carbon foil, and (2) surface conversion-electron pickup by electronegative atom during surface scattering. The first provides acceptable overall sensitivity for any energetic atom at energies above a few keV, while the second is effective for electronegative atoms (e.g., H and O) at energies below 1 keV. Grazing incidence on a conversion surface refers to atomic impact trajectories with angles of incidence of 1 degree or less to guarantee multiple small angle scattering events that enhance the probability of charge transfer. Laboratory data exist to support this approach for electronegative atoms at energies from just above 1 keV to 20-40 keV with good conversion efficiency. This paper will present a brief review of energetic neutral atom imaging, describe the GINA approach with possible implementation schemes and discuss its advantages and disadvantages.

Magnetospheric plasma pressure restored from the magnetic data

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The magnetostatic equilibrium equation with the anisotropic pressure has been solved, the ratio of the transverse pressure to the parallel one being assumed to grow with the geocentrical distance. The equation allows to restore the pressure up to some unknown function of the distance which appears to be not too large. The empirical model of the magnetic field by Ostapenko et al. [1996] plausible for the distances from 3 to 10 earth radii was used. The model depends on Dst, Kp, and AE indices, as well as on MF Bz and the solar wind dynamic pressure. The radial profile of the magnetospheric plasma pressure computed for quiet conditions is similar to that obtained from direct measurements. Influence of the five above-mentioned parameters on the pressure was studied. The magnetospheric pressure appeared to be affected mainly by the solar wind dynamic pressure and Dst index.

ARE OUR IDEAS ABOUT DST CORRECT?

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Since the sixties of this century we have generally the idea of two seperate storm time ring ring currents, a symmetric and an asymmetric one. Thereby it was concluded from Dst the real existence of a symmetric equatorial ring current. However, on the other hand from the asymmetric development of the low latitude geomagnetic disturbance field during storms it was concluded the real existence of an asymmetric ring current. I think it is time to inquire whether this conception is correct.
In order to answer this question I have investigated the development of the low latitude geomagnetic field at all magnetic local times during disturbed and quiet conditions. The storm on February 8/9, 1986 as well as a statistic analysis of many storms has shown that the asymmetry does not vanish during the storm recovery phase. The ratio between the recovery phase asymmetry and the main phase asymmetry is low only for strong storms and not for less strong storms. The global picture of the field evolution of the February storm shows clearly differences at different local times. For instance the main phase and recovery phase start time does not agree with Dst. On the other hand the ring current decay is different at different local times. Therefore, Dst gives an incorrect picture of the field development.
Morever, also the investigation of the low latitude magnetic field during international quiet days shows not a disappearing of the asymmetry.
Taking into account all these observations I think we must revise our picture which we have about the ring current. I have the opinion that exists only one ring current which is asymmetric. This asymmetry increases during storms and develops rather fast to more or less symmetric conditions. However, in no case it is justified to conclude from Dst an existence of a symmetric ring current.

ORDERING OF ELECTRON ANISOTROPY IN THE LOW-LATITUDE BOUNDARY LAYER

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Enhanced fluxes of 100 eV to 1 keV electrons parallel and anti-parallel to the magnetic field are observed during most crossings of the low-latitude boundary layer (LLBL). We show that these "counter-streaming electrons" are well-ordered by the magnetopause transition parameter of Hapgood and Bryant (1992). which also orders other independent quantities such as the magnetic field and ion bulk velocity. These results will be discussed in the context of a reconnection model of the LLBL.

THE MAGNETOPAUSE TRANSITION PARAMETER AND THE WHALEN TEST

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The magnetopause transition parameter, which is derived from the electron number density and perpendicular temperature in the low-latitude boundary layer (LLBL), has a remarkable ability to order other independent plasma parameters such as the components of the magnetic field. We present here new results showing that the transition parameter can also be used to select magnetic field and ion bulk velocity data for the Whalen test. This test is a quantitative test for the presence of magnetohydrodynamic discontinuities threaded by a normal magnetic field, the existence of which is predicted by the reconnection theory of the LLBL. This provides further support for suggestion that the transition parameter works because it is directly related to the time since a flux tube was reconnected.

MAGNETOPAUSE MOTIONS AS OBSERVED BY GEOTAIL SATELLITE

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Geotail is a favourable spacecraft for dayside magnetopause studies due to the existense of "scimming" passes, when the spacescraft moves along the magnetopause surface for long times. A survey of Geotail magnetopause observations in 1995-97 is presented. Surface motions are studied statistically considering multiple crossing occurence rate. Multiple crossings are an indication of quasiperiodic motions and surface waves on the magnetopause. Such motions are found to be more pronounced for directions of the magnetic fields in the magnetosheath and in the magnetosphere close to parallel and antiparallel. and high solar wind velocities. This latter dependence is, however, less significant than sometimes suggested. Directions of the normal to the magnetopause were determined using minimum variance technique. The deflections in the east-west direction were found to be larger than those in north-south plane, indicating north-south aligned ridges propagating azimuthally. Examples of quasiperiodical motion of the magnetopause and extremely large magnetopause expansions are presented and their possible nature is discussed.

IMP 8 OBSERVATIONS OF MAGNETICALLY OPEN MAGNETOTAIL DURING EQUATORIAL IMFs: IMPLICATIONS FOR RECONNECTION

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Magnetic field vector maps derived from IMP 8 spacecraft in the magnetosheath and magnetotail at -30 Re show the global geometrical properties of the magnetically open magnetosphere. During strong equatorial IMFs, both the magnetosheath and the magnetotail magnetic fields undergo several asymmetric behavior in a manner which will be caused by the dayside reconnection of the IMF y-component with the Earth's northward dipole field lines at the magnetopause. The draping of the magnetic field lines around the magnetosphere shows a strong twist with respect to the concurrent IMF direction. The partial penetration of the interplanetary magnetic field, concentration of the penetrated fields along the tail's flanks, unequal rotation of the tail's current sheet, twisting of the tail field lines are observed in the magnetotail. When one combines these signatures observed in the magnetosheah and tail, they can be interpreted as the signatures of the magnetopause reconnection mapped at 30 Re in the magnetotail. MHD model results for strong equtorial IMFs show the similar features as in IMP 8's magnetic field maps. The plasma data from IMP 8 will also be presented and the features seen in both the field and plasma maps will be discussed in terms of the signatures of the dayside reconnection.

SUBSTORM DIFFERENTIAL MAGNETOSPHERIC CURRENTS ESTIMATED BY CRRES DATA

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Magnetic field variations from the CRRES spacecraft at the midnigth sector of the magnetosphere are studied to estimate the changes in the near-Earth cross-field current. The differential vectors of the magnetic field dB(t)= B(t+dt) - B(t) have been used to identify the current perturbations during the individual substorm activations. Two models of the currents have been used to interpret the magnetic field perturbations. First model is the line current model. We assume that the equivalent current restricted to the equatorial plane has arbitrary orientation. Another one is the current loop model contained cross-field current in the plane of dipole magnetic equator and the field-aligned currents. The direction of current in the loop may be arbitrary. We investigated a few substorms. Large changes of differential currents, such as rapid dynamical changes in the location, magnitude and orientation of the perturbation current, occur in the region where the local magnetic field dipolization is observed.

POSSIBILITY OF TOMOGRAPHIC INVESTIGATION OF MAGNETIC RECONNECTION IN EARTH'S MAGNETOSPHERE

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Several regimes have been proposed for the process of magnetic field lines merging. However, it is unclear which of them actually takes place in Earth's magnetosphere and it's fine structure is not yet defined, because untill recently most of the data, concerning magnetosperic substorms and reconnection on the day-side of plasmapause contained only integral features of the phenomenon.

A method of radiosounding by several sattelites is proposed to be applied to reconstruct plasma density and magnetic field distribution in the most crucial regions. Various schemes of sattelite orbits are proposed. Computer simulations with different plasma configurations and velocities predicted by theories and recent observations are used to estimate the most appropriate conditions for the geometry of the experiment and the precision of the results.

OVERVIEW ON THE INNER MAGNETOSPHERE VARIATIONS OBSERVED BY LIULIN INSRTUMENT ON MIR SPACE STATION

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A comprehensive overview of all LIULIN observations in the inner magnetosphere is presented. The fixed locations of the instrument in the MIR manned compartment behind 6-15 g/cm^2 of shielding have permitted homogeneous series of particle fluxes and doses data to be obtained during the declining phase of 22nd solar cycle between September, 1989 and April, 1994. An analysis of the dynamics of the observed in the inner magnetosphere "main", "second" and "new" radiation maxima is presented. The measured data are compared with the UNIRAD model values, which have been obtained with the latest version of the software package, developed for ESA at the Belgian Institute for Space Aeronomy.

THE SPATIAL STRUCTURE OF MHD - OSCILLATION FIELD, EXCITED IN THE MAGNETOSPHERE BY LOCAL MONOCHROMATIC SOURCE IN THE IONOSPHERE

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We have constructed a theory for standing Alfven waves driven in the magnetosphere by a monochromatic source localized in the ionosphere. It is shown that a dominant role in such oscillations is played by harmonics with large azimuthal wave numbers with $m \gg 1$. We explore the possibility of such oscillations being excited during active experiments on periodic (with the period of Alfven eigenmodes of the magnetosphere) ionospheric modifications. Our study has made it apparent that the measured distance between local maxima of the amplitude of oscillations excited in such an experiment can be used to infer the value of the polarization splitting of the spectrum between poloidal and toroidal eigenmodes of the magnetosphere.

MAGNETIC EFFECTS OF FIELD-ALIGNED CURRENTS

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The calculation of magnetic fields values from field-aligned currents (FAC) is fulfilled in the subsolar point and near equator on the magnetosphere night side. It was realized with using IZMEM model where $FAC(\Phi, MLT, B_z, B_y)$ are determined in the area poleward from $\sim$ 60 deg for three seasons as function of B_z and B_y IMF [1]. The role of magnetic fields from FAC in the processes of interaction solar wind with magnetosphere and 'depolarization' of geomagnetic field lines in the period of magnetospheric disturbances is very serious. Besides values of the magnetic field connected with movement FAC only in the period of substorm were calculated in points where AE index stations are located. These magnetic field values may be equal $\sim$ 20% of AE amplitude. The magnetic field variations calculating with the IZMEM field-aligned currents model are compared with TRIAD and MAGSAT satellites measurements. FAC influence on cosmic rays in the polar cap is also analyzed. It is shown that the magnetic field from $FAC(\Phi, MLT)$ create the daily variation of cosmic rays intensity.

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Effects of Bz and By IMF Components on the Dst variation

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We have studied the response of the hourly Dst index to the IMF By component in several ranges of the IMF Bz. Processing the data throughout the 28 year period showed no distinct dependence of the response of Dst on the IMF By in all the ranges of Bz. At the same time the dependence on Bz is clearly seen at any By. Hence one can conclude that the storm activity is controlled by the magnetic flux transport from the dayside to the magnetotail rather than by the energy input into the magnetosphere.

Storm Effect on the Bulk Magnetic Field in the Magnetosphere

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We used 60,000 magnetic measurements from the database of Fairfield et al. [JGR, 1994, V.99, 11319] for studying the differential response of the magnetic field at distances of -30 Re < X < 10 Re to changes in the Dst index. The response results in increasing of both the cross-tail and ring currents. An interesting peculiarity of the storm time depression is the absence of positive variation of the magnetic z-component throughout the magnetosphere that evidences the dominant role of the cross-tail current.

ON THE SELFCONSISTENT PROFILES IN COLLISIONLESS PLASMA WITH ADIABATIC PARTICLE MOTION

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The technique is proposed to obtain the selfconsistent profiles in collisionless plasma, which considerably facilitates both the calculation of the particle orbits and the electromagnetic field. The orbit calculation is performed implicitly using the adiabatic approximation with the corresponding integrals of motion being taken into account. The field calculation is considerably simplified due to the appropriate curvilinear coordinates. The technique is designed to become a modification of particle-in-cell codes [e.g., Birdsall and Langdon, 1985]. The simplest model, which demonstrates the merits of the technique, describes the cloud of plasma in the dipole magnetic field with application to near-equatorial plasma of the inner magnetosphere (4<L<10) [Lemaire and Scherer, 1974]. Another possible application of the technique deals with the modeling of the plasma convection in the near-Earth magnetotail [Pritchett and Coroniti, 1995].

PENETRATION OF THE SOLAR WIND PLASMA INTO MAGNETOSPHERE

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The penetration of the charged particles along open field lines is calculated in a spherical magnetospheric model. This simplest model allows to obtain analytical expressions for the magnetospheric magnetic and electric fields. The distribution of plasma density inside the magnetosphere was determined by its value at the magnetopause. Simulations were perfomed along the magnetic open flux tubes for the energetic paticles. The drift approximation is used.

MECHANISMS OF FORMATION OF THE OBSERVED PECULIARITIES IN ENERGETIC ELECTRON SPECTRA IN THE EARTH'S MAGNETOSPHERE.

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During the two last cycles of solar activity (21 and 22 cycles) the data on spectra and fluxes of energetic electrons were obtained onboard satellites "Molnija-1", "Intercosmos-19", "Cosmos-1686" by means of the same type of an electron spectrometer. Stable phenomena for differential energetic spectra of electrons were obtained: a) "maximum" for energies E_e~1 MeV in the outer radiaiton belt on L=3.0-4.5 during quiet geomagnetic periods (D_{st}≤-30 nTl); b) "minimum" or "plateau" for energies E_e~0.6-1.0 MeV in the inner radiaiton belt on L=1.1-1.3 independently of geomagnetic conditions. The impact of solar activity on the magnitude of these phenomena is considered. The cause of the "maximum" appearance is presumably the energy dependence of the electron life time which is connected with scattering due to wave-particle interaction of electrons and ion-cyclotron waves. The mechanism of acceleration under the influence of quasiperiodic electric field is used to explain variations of energetic electrons in the inner radiaiton belt. For instance, geosyncronous acceleration, when electrons are resonantly accelerated by fluctuations of electric field, created by ionospheric currents modulations.

NONGYROTROPIC GYRATING ION DISTRIBUTIONS AND LOW FREQUENCY WAVES IN THE EARTH'S FORESHOCK: A DETAILED CASE STUDY

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We exhibit the 3D structure of gyrating ion distributions observed upstream from the Earth's bow shock, using WIND/3DP experiment. According with previous observations, these distributions are associated with quasi-monochromatic low frequency electromagnetic waves. Complete correlative analysis of the particle and magnetic field data is performed. This study indicates several evidence for wave-particle interaction. Then we use the observed plasma parameters to solve the linear Maxwell-Vlasov dispersion relation. We compare the theoretical predictions with the observations and discuss the possibility of nonlinear trapping.

Qasistatic Electric Fields in and near the Northern Cusp

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The electric field double probe experiment on Polar yields information about the quasistatic convective component of the electric field in a tenuous plasma provided that the magnetic field direction relative to the spacecraft is favourable. A number of cusp crossings, selected for good analysis conditions, have been studied on the background of classes of solar wind conditions. Average convections, often below the sensitivity threshold of particle experiments, can be determined. Field-aligned flow on polar field lines influences the electric field measurements and complicates data analysis. However this may also be turned into a useful indicator of ion flow out along the magnetic field; this is at present a topic at an early stage of preparation.

DEPENDENCE OF UPSTREAM ION BEAM DENSITIES UPON DISTANCE FROM THE EARTH'S BOW SHOCK

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The Earth's bow shock reflects continuously a small portion of the incident solar wind ions, and these propagate against the flow, roughly along the interplanetary magnetic field direction. These ions travel a significant distance from the shock. Reflected ion beams provide a source of free energy for instabilities, yet can be seen a significant distance ($> 40R_E$) from the shock. Waves are excited, wich in turn induce pitch-angle scattering, leading to a nearly isotropic distribution function. In the case of an electromagnetic ion-ion beam instability, an attenuation of the ion beam density would be expected. We report on WIND-3DP observations, and show that there is a strong correlation between the ion beam density and the observed beam location from the bow shock. We also find that near the shock the range of densities is small. We discuss these observations and compare them with theoretical predictions about wave-particle interactions occuring in the Earth's foreshock.

MULTI-SPACECRAFT STUDIES OF SUBSTORMS

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We present Interball-Tail and Geotail observations of substorms as a good example of the newly available multispacecraft data. Interball-Tail in a high inclination orbit and Geotail in an equatorial orbit well complement each other. Starting from the 1995, four months of joint observations during every winter season are available. However, even in such a case, spacecraft conjunctions which permit to make precise timing and scaling of substorm signatures are very rare. In one such event detailed studies of an isolated activation on November 28, 1995 have shown that: Reconnection onset occurred at $X = -15R_E$ and produced the tailward moving plasmoid and earthward bursty flows. The bright auroral break-up was delayed by 1-2 minutes after the onset of tail reconnection. Another approach to the analysis of multispacecraft data is comparison of measurements taken at different magnetospheric regions. An important baseline for such studies is availabibily of suitable magnetotail models. We compared simultaneous pressure measurements by Interball-Tail in the high-latitude lobe and by Geotail in the plasma sheet. In few substorms the plasma sheet pressure peaks were observed at the onset. During expansion and recovery phases of many substorms the plasma sheet pressure depletions (relative to lobe pressure) were found. We are grateful to many members of Geotail and Interball teams for the measurements, presented in this report.

THE SOLAR WIND FLOW AROUND THE EARTH IN THE CGL APPROXIMATION

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Parameters of the magnetosheath plasma and magnetic field are calculated in the Chu–Goldberger–Low approximation. The pitch-angle diffusion of protons is taken into account. The comparison of the results of calculations with experimental data allowed to estimate the characteristic time of the temperature anisotropy relaxation as 100–300 sec

THE SOLAR WIND FLOW AROUND THE EARTH IN DEPENDENCE ON THE MAGNETOPAUSE BOUNDARY CONDITIONS

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The influence of the magnetopause boundary conditions on the solar wind flow around the magnetosphere and on the magnetosheath parameters is investigated by means of numerical simulation. There is shown that the erosion and flattening of the magnetopause during the periods of the southward IMF results in the increase of the magnetic field intensity in the magnetic barrier region. Electric currents distribution in the magnetic barrier and in the magnetopause is studied.

S14

ON A POSSIBLE SOURCE OF GLOBAL PI2 PULSATIONS ON MIDLATITUDES

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Observations from the Norilsk meridional chain of stations ($\Lambda = 160°$. $\Phi = 40°$-75° and a network of midlatitude observatories were used in the analysis of excitation patterns of midlatitude Pi2 pulsations at periods of auroral substorm development. In the midnight-evening sector of the magnetosphere, the dynamic spectrum of auroral Pi2 has a noisy character, while in midlatitudes only one dominant period is traceable in the Pi2 spectrum. In the midday sector of the magnetosphere, the maximum of meridional intensity distribution of Pi2 pulsations lies at latitudes of statistical plasmapause projection. In the auroral zone, daytime Pi2 pulsations either are not observed at all or have an amplitude comparable with midlatitudes. Investigations of Pi2 pulsations using data from a global network of midlatitude observatories showed that these pulsations appear almost simultaneously at all stations, and dynamic spectra exhibit a single dominant period recurring from station to station. It was also ascertained that in most cases the longitudinal sourse size of midlatitude Pi2 pulsations exceed the source size in the auroral zone. Our studies suggest that Pi2 pulsations observed in midlatitudes are not the propagation effect from the source in high latitudes but are caused by the development of a global mode in the inner magnetosphere during auroral substorms.

ON THE WAVE PROPAGATION AND POLARIZATION OF ELF EMISSIONS OBSERVED BY FREJA AROUND LOCAL PROTON GYRO-FREQUENCY

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We investigate the propagation and polarization characteristics of electromagnetic emissions around the proton gyro-frequency (f_{H+}) in the auroral and sub-auroral regions. The data of the low-orbiting Freja satellite are examined using a multicomponent measurement of electric and magnetic field in ELF range. We confirm previous results on the properties of high-latitude hiss with a sharp cut-off just below f_{H+}. The waves are down-going and their reflection at lower altitudes could explain the up-going emissions on both poleward and equatorward edges of the hiss. The high latitude emissions below f_{H+} contain right-hand circularly polarized waves often propagating parallel to the terrestrial magnetic field. A statistical study shows that these emissions occur outside the plasmasphere, mainly at auroral latitudes. The maximum wave power is observed before the local noon, and no events have been detected during the local night. The analysis shows nearly circular and right-handed polarization and downward nearly field aligned propagation. An experimental estimation of phase velocity modulus is in a rough agreement with the cold plasma theory. The origin of these emissions could be possibly explained by the tunnelling of the down-going auroral hiss below the two-ion cut-off frequency.

DYNAMICS OF TAIL-LIKE CURRENT LAYER CAUSED BY ANOMALOUS RESISTIVITY

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A two-dimensional MHD-model of magnetic reconnection in a plasma with different types of microturbulence excited locally at different distances from the magnetic neutral line is proposed. It is supposed that an anomalous resistivity pulse with a peak at the magnetic neutral sheet, may be caused by some current-driven instability, initiates the reconnection process. Additionally, the lower-hybrid-drift (LHD) instability is generated by the density gradients of the current layer. It is assumed that the LHD-instability is saturated by current relaxation. Then the temporal and spatial evolution of the electromagnetic field, the plasma density, pressure and convection are numerically found. The feedback of the temporal changes of the MHD-parameters on the anomalous resistivity is considered. It is shown that the anomalous resistivity causes in the current sheet a series of MHD-waves, fast magnetoacoustic compression and rarefaction waves, as well as slow magnetoacoustic waves.

PLASMA CONVECTION IN THE NEAR-POLE REGION OF IONOSPHERE AND THE STRUCTURE OF POLAR CAP

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It is known that the near-pole region of ionosphere (diameter about 10 degrees of latitude) is almost always free of precipitating energetic particles during both the southward and northward IMF. This paper will show in addition that the field lines, threading the above-mentioned near-pole region, do not take part both in the global two-cell plasma convection and in the energy transport from the solar wind to the magnetosphere, even when the IMF is southward. This paper proposes a model of the magnetic tail with two essentially different parts. The external part consists of field lines connected with the southward IMF which takes them away to a distance L1 where they reconnect and return (as in the Dungey model). The internal part of the tail consists of field lines with length L2>L1, which do not take part in the convection caused by dayside magnetic merging. Therefore, plasma convection flows round the near-pole region. This feature of the convection system is equivalent to the existence of field-aligned currents of zone 3' observed both in the daytime and in later hours. The analogy of the proposed model with Cowley-Lockwood's "concept of zero-flow equilibrium" is discussed.

INTERHEMISPHERIC PROPAGATION OF HF WAVES IN THE MAGNETOSPHERE

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A trough located at low and middle latitude magnetosphere is capable to guide interhemispheric HF waves. In this paper ray tracing results on guidence of HF waves in magnetosphere are presented. HF waves in frequency range from 3 MHz to 58 MHz can be guided by a trough located at L = 1.214. All these waves were started at 500 km altitude with initial wave normal directed parallel to geomagnetic field. As the wave frequency increases it is necessary to reduce the effective width of the trough. To guide several tens of MHz, a trough has to be modeled with extremely severe negative electron density gradient. For these frequencies, ray path excursions from the trough center are very small along the whole path. The angle between wave normal and the geomagnetic field direction has values $|\psi| < 1^0$. In the middle latitude magnetosphere (summer day model) HF waves from 2 MHz to 10 MHz can be guided by a trough at L = 2.74. The interhemispheric propagation of higher frequencies from this range is obtained with very severe negative electron density gradient in a trough. In all these cases wave propagation is parallel to geomagnetic field direction and refractive index differs for negligible amount from 1. The initial conditions providing magnetospheric guiding emerge from ionospheric irregularities in assumed $N_e(h)$ profile.

The Development of the First Substorm on January 10, 1997

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The interplanetary high-speed stream measured by WIND and the resultant first substorm is studied using Polar UV images. A 47 minute interval of relatively intense southward directed fields (4 to 8 nT) is identified sunward of the interplanetary shock and antisunward of the magnetic cloud. Magnetic reconnection through the southward component of the IMF serves to only transfer solar wind energy to the magnetosphere. No substorm expansion phase occurs during the interval. The substorm onset occurs a good 20-30 minutes after passage and is not related to either northward or southward IMF turnings. This substorm example clearly illustrates that this energy release event was a result of a loading-unloading process and was not directly driven. There was a UV auroral latitude discontinuity at local midnight during the loop event. Both a sun-earth aligned (theta) aurora and an auroral pseudo-breakup were collocated with the latitudinal discontinuity. The aurora developed into a horseshoe shape (an oval with a lack of emission in the noon sector) during the B_s event. With increasing time, the dawnside aurora became much brighter than that on the duskside. Dawnside PCBL broadband waves and ion fluxes were well correlated. This locally accelerated ion population could serve as the seed population for the later magnetic storm ring-current.

A LONG TERM PHYSICAL MODEL FOR HIGH ENERGY LOW ALTITUDE PROTONS

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The physical proton model SALAMMBÔ 2D developped by the ONERA-CERT SPatial Environment Department simulate a radiation belt state in the equatorial plane for known magnetospheric conditions.
Starting from a stationary state of the magnetosphere, we want to reproduce the long term influence of the solar cycle on high energy proton fluxes using the 10.7cm solar flux variability. This solar activity interferes especially at low altitudes in source processes throught the CRAND phenomena, and also in loss processes throught thermosphere density variations. Compared with TIROS/NOAA satellites high energy protons measurements from 1976 to 1996, results are quite satisfying. More than following correctly solar cycle variations observed in proton fluxes intensities, the code shows the effects of magnetic field secular variation, so the possibility to reproduce temporal variation of South Atlantic Anomaly position for different low altitude orbits. On the other hand, using the MSFC estimated 10.7cm solar flux, this model is capable to make predictions for cycles 23 and beginning of 24.

LINEAR CORRELATIONS BETWEEN THE GLOBAL GEOMAGNETIC INDEX KP, CRRES IN FLIGHT MEASUREMENTS, AND SALAMMBO 2D PROTON CODE RESULTS

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ONERA-CERT SPatial Environment Department has developped a physical simulation of the radiation belts dynamics for known magnetospheric conditions called the SALAMMBÔ codes. Part of the problem now is concentrated on a good description of the occurence of these magnetospheric conditions taking into account solar and magnetic variability.
Because of several practical and scientific reasons, that we will state about, we have payed a particular attention to the global geomagnetic index Kp throught a series of linear correlations with CRRES in flight measurements of protons fluxes in order to find a possible easy description of storm phenomena.
In the other hand, linear correlations between CRRES low energy proton fluxes measurements and SALAMMBÔ 2D results have been made in order to validate the code and to understand the way of influence of the Kp index that is used as an entry in this numerical code.

VIEWING THE DIPOLARIZATION REGION DURING SUBSTORM ONSET

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Using magnetospheric sounding method and method of midlatitude magnetogram inversion we showed that the dipolarization region in the magnetotail can be seen near the ionosphere by observing pitch-angle distributions of energetic particles at low altitude spacecraft. We studied the temporal and spatial evolution of boundaries of this region and estimated the region and boundary dimensions during substorm onset for 20 events. The results are analyzed in terms of the impulsive magnetotail reconnection concept.

CIR RELATED SUBSTORM ACTIVITY OBSERVED IN THE DISTANT TAIL

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The passage of coratating interaction regions (CIR) caused quiet regularly periods of 10 or more days with enhanced allthough moderate magnetospheric activity. During such intervals GEOTAIL observed energetic particles in the distant tail (at about 200 RE). Manifestation of substorm signatures both in the dawn/dusk magnetosheath and in the central part of the tail are discussed. Significant compositional changes (relative helium and oxygen content) are observed in the course of substorms.

Nonlinear Mechanism of Electromagnetic Radiation in the Magnetized Plasma.

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The satellite EXOS-D [1] observations show that most stability modes in the magnetosphere of the Earth in the region high frequency ($\omega<\omega_{Be}$ - electron cyclotron frequency) is the upper hybrid wave. In the [2] after analysis of the satellite observations ware found the electromagnetic waves with frequencies order upper hybrid waves (UHW) in the same region of the magnetosphere. Presence of the different wave modes in the emission region suggests us that the nonlinear decay processes may take place in this region. The decay of the UHW on the electromagnetic wave which propagate along (across) of the external magnetic field and kinetic Alfven wave (KAW) studied in this paper. Two-fluid magnetohydrodynamics is used for the description of the waves nonlinear parametric interaction. The nonlinear dispersion equation is found. We found also the instability growth rate γ and characteristic time τ. In general, the characteristic time in case decay UHW on the left polarized electromagnetic wave and KAW much less of the characteristic time in case decay UHW on the ordinary electromagnetic wave and KAW. Consequently, after decay of the UHW more effective stimulate the left polarized electromagnetic wave. Our results used for explain of the low frequencies electromagnetic radiation in the magnetosphere of the Earth [2].

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ST5 Open session on solar and heliospheric physics

Convener: Marsden, R.G.
Co-Convener: Marsch, E.

STUDY OF HELIUM ABUNDANCE IN LOW-SPEED SOLAR WIND STREAMS ON THE BASIS OF PROGNOZ 7 AND 8 DATA

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Prognoz 7 and 8 measurements of relative helium abundance n_α/n_p in slow solar wind at the Earth's orbit distance are analyzed. The data confirm a result that n_α/n_p strongly decreases when satellite crosses a region of the interplanetary magnetic field polarity change. We extrapolate this region back to the Sun (to so-called source surface at 2.5 Sun's radii) with formula for expansion time $t = Ar/v$, where r and v are the astronomical unit and minimum solar wind bulk velocity near IMF polarity changing, respectively, and coefficient A estimated from measurements is about 1.1. The region of IMF polarity change is connected with neutral line of global magneic field of the Sun, that is a projection of symmetry plane of low latitude streamer.

LARGE-SCALE ANOMALOUS RESISTIVITY CAUSED BY ELECTROSTATIC ION-CYCLOTRON TURBULENCE IN THE PLASMA OF THE AURORAL IONOSPHERE

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The momentum and energy balance of the plasma above the auroral ionosphere is numerically investigated, assuming an excitation of electrostatic ion-cyclotron (EIC) waves. and taking the magnetospheric convection and the thermal fluxes of the plasma into account. It is shown that the anomalous resistivity of the turbulent plasma causes large-scale differences of the electrostatic potential along the magnetic field lines. The potential differences then provide the heating and acceleration of the thermal and energetic auroral plasma. It is found that in the quasi-steady state, electrostatic ion-cyclotron turbulence may cause differences of the electric potential of 1–10 KeV at altitudes of $500 < h < 10000$ km above the Earth's surface. In the turbulent region, the ratio between the electron and proton temperatures strongly depends on the value of the model parameter $C = \Delta V_\perp/\Phi$, where $\Delta V_\perp$ is the electric potential across the magnetic field, and Φ is the magnetic flux in the turbulent flux tube. For small values of C, the heating rate of the electrons is larger than the heating of the protons. This may result into an excitation of the ion-acoustic instability. For larger values of C, on the contrary, the heating of the protons is larger than the heating of the electrons. In this case, the weak thermal proton conductivity cannot prevent the increase of the proton temperature. and the EIC turbulence may be damped.

ST5

SOLAR WIND INTERACTION WITH THE PHOBOS GAS TORUS: PHOBOS EVENTS

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Following recent simulations of the Phobos dust belt formation (Krivov and Hamilton, 1997) the effective dust-induced charge density when is estimated is too small to account for the significant solar wind (sw) plasma and magnetic field perturbations observed by the *Phobos*-2 spacecraft in 1989 near the crossings of the Phobos orbit. In this contribution the comet-like sw interaction with the Phobos neutral gas torus is re-investigated in a two-ion plasma model in which the newly created ions are treated as unmagnetized, forming a beam (not a ring beam) in the sw frame. A linear instability analysis based on both a cold fluid and a kinetic approach shows that low-frequency electromagnetic ion beam waves may aquire high growth rates and provide a likely mechanism to cause the observed events.

COMETARY PLASMA TAILS AS PROBES OF LATITUDINAL STRUCTURE IN THE SOLAR WIND

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The in situ measurements by the Ulysses spacecraft clearly show the demarcation of the solar wind into equatorial and polar regions. The Ulysses Comet Watch was organized as part of an Interdisciplinary Science program to explore cometary properties as latitudinal solar-wind probes. Three comets with high inclination (i) appeared recently which made this study possible: de Vico (C/122P) in 1995, i=85.4°; Hyakutake (C/1996 B2) in 1996, i=124.9°; Hale-Bopp (C/1995 O1) in 1997, i=89.4°. Monitoring these comets as they traversed the heliosphere revealed the following behavior: (1) The appearance of the plasma tail in the polar region is relatively undisturbed as expected from a steady solar wind. The appearance in the equatorial region is disturbed as expected from a region with large variations in solar wind properties; (2) Disconnection events (DEs) occur only in the equatorial region where comets pierce the heliospheric current sheet (HCS); (3) Solar-wind speeds as determined from the position angle of the plasma tail are consistent with average values of 750 km/sec for the polar region and 450 km/sec for the equatorial region. We note that there may be an anomalous orientation for comet Hale-Bopp at the highest latitudes. These results show that the properties of the different regions are clearly reflected in comets. Thus, the plasma tails of comets can be used to map the heliosphere in the future.

Interplanetary Scintillation measurements of the Solar Wind during Whole Sun Month

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The EISCAT facility was used to make more than 140 observations of solar wind velocity during the Whole Sun Month in August-September 1996, when co-ordinated measurements from ground-based observatories and instruments aboard the SOHO, Wind and Ulysses spacecraft provided a comprehensive set of measurements covering a full solar rotation. The EISCAT IPS measurements are of great importance as they provide a direct estimate of solar wind velocity between 15 and 100 solar radii (R), and so form an essential link between coronal observations and in-situ measurements at 1 AU (215 R) and beyond.
In this paper we discuss IPS observations of the solar wind above a large low-latitude coronal hole (the "Elephant's Trunk") and discuss their relationship with coronal features and structures detected by in-situ measurements at 1 AU and beyond

Acceleration of the Solar Wind: Measurements of irregularity velocities and model results

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Observations of the fast, high latitude solar wind have shown that acceleration of the fast wind is complete by 10 solar radii (R), while measurements from the LASCO instrument on SOHO have suggested that the acceleration may take place inside 5 R.
A series of observations were made in September 1997 using EISCAT and the C2 and C3 coronagraphs aboard SOHO to measure the solar wind velocity profile from 3 R out to beyond 30 R. The overlapping fields of view of the instruments allowed direct comparisons to be made between IPS and optical estimations of flow velocity.
In this paper we present the results of these observations and discuss the constraints they put on models of solar wind acceleration, in particular the latest version of the Lindau-Warsaw model of fast wind acceleration.

ON THE APPLICABILITY OF FLUID-MECHANICS APPROACH IN THE MODELLING OF INTERSTELLAR HYDROGEN GAS WITHIN THE HELIOSPHERE

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It has been clearly seen for decades now that interstellar neutral gases enter the inner heliosphere where they are subject to many ionizing processes. As reflected by large mean free paths both for elastic and charge exchange collisions, the kinetic theory based on the Boltzmann integro-differential equation is suggested as the natural means of description. To avoid, however, the highly time-consuming computational efforts connected with a kinetic theory, attempts have recently been made to describe the neutral heliospheric gas as a hydrodynamic fluid with density, bulk flow, and scalar temperature as properties. Higher velocity moments of the neutral fluid are neglected. We shall show how the validity of this approach can be checked and determine a critical region around the sun inside of which this approach is invalidated.

PHYSICAL PHENOMENA DETERMINING INTERSTELLAR HYDROGEN DISTRIBUTION IN THE INNER HELIOSPHERE

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Various physical phenomena affecting the distribution of density, velocity and temperature of the interstellar hydrogen gas in the inner heliosphere will be analysed. The role of the heliospheric interface, which seems to rarefy, slow down and heat the inflowing interstellar gas, will be discussed. The influence of solar cycle effects on the distribution taking into account the actual data on charge exchange, photoionisation and radiation pressure will be presented. The critical importance of accurate modelling of the ionisation rate and the radiation pressure, including the konwledge of the flux ar central part of the solar Lyman-α line profile, will be stressed. It seems that uncertainties in the knowledge of the ionisation rate and radiation pressure due to calibration discrepancies between spaceborbne instruments adversely affect the quality of interplanetary hydrogen modelling to the extent comparable or higher than deficiencies of the mathematical models used.

ANALYSIS OF A ^{3}HE RICH SOLAR ENERGETIC PARTICLE EVENT OBSERVED WITH ACE/SEPICA AND SOHO/HSTOF

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We present new results on the energy dependence of the ^{3}He/^{4}He ratio in impulsive solar energetic particle events (SEP) from observations of the 1997 September 19-21 SEP event carried out simultaneously by two instruments with complementary energy ranges, the Solar Energetic Particle Ionic Charge Analyzer (SEPICA) on ACE and the time-of-flight mass spectrometer HSTOF on SOHO. The two instruments have a combined energy range from $\approx$ 0.1 to 3.5 MeV/nuc. We observe a strong increase of the ^{3}He/^{4}He ratio with energy, starting with $\leq$ 0.1 at the lower end and reaching $\approx$ 1 at the upper end. This is in agreement with previous ISEE observations and extends their energy range to lower values. We discuss the observed energy distribution within the context of models for the selection and acceleration mechanisms in compact flares.

FLOW SHEAR AND MAGNETIC FIELD ORIENTATION AT SOLAR WIND DIRECTIONAL DISCONTINUITIES: WIND OBSERVATIONS

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We examine the relation between the magnetic field and flow changes across directional discontinuities (DDs) in slow and fast solar wind streams at 1 AU as observed by WIND. The magnetic field rotation sense in the fast wind is that predicted by the MHD theory of rotational discontinuities (RDs), although there are significant deviations from the theory. DDs with small normal component can be regarded as tangential discontinuities (TDs); in the context of a kinetic TD model the observations are found to imply that the length scale over which the proton velocity distribution changes at the TD can be both smaller or larger than that of the electron distribution, a finding that constrains TD formation theories. Flow shear effects appear to be less important in slow wind DDs.

ANALYSIS OF TRANSPORT CONDITIONS OF ENERGETIC HELIOSPHERIC ELECTRONS (WIND AND GEOTAIL DATA)

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It is difficult to differentiate spatial from temporal variations of plasma phenomena with only one spacecraft - except in special cases e.g. abrupt changes at the other parameters (magnetic field, ions, solar wind parameters etc...). The WIND and GEOTAIL spacecraft are particularly interesting for such analysis. When the WIND spacecraft is at the Lagrangian point, it is separated from the near-Earth GEOTAIL spacecraft by about 10^6 km (but a comparison is only valid when the latter is in the solar wind). On the 09 July 1996 both spacecraft measured, simultaneously, a classical diffusive energetic (> 30 keV) solar electron event. However, it took about 15 minutes and 2 hours, respectively at GEOTAIL and WIND, for the flux to reach its maximum; both maxima had comparable intensity values. This suggests that the two basic processes accounting for the flux profiles of solar energetic electrons at a given distance from the Sun, namely the injection and transport conditions, are very likely to be time or spatial dependent.

PARTICLE ACCELERATION EFFICIENCY AND MHD CHARACTERISTICS OF CIR RELATED-SHOCKS

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During its southbound journey the Ulysses spacecraft had several encounters with so-called corotating interaction regions (CIRs) which build up due to the interaction of fast and slow solar wind streams. We analyse the forward and the reverse shocks marking off the 18 CIR encounters between July 1992 and December 1993. Our investigations look for a correlation between the particle acceleration efficiency expressed by the particle flux measured at the time of shock crossing and the MHD characteristics of the shocks; i.e., Alfven-Mach number (M_{A1}), density and magnetic field compression ratios (r_N, r_B), and the angle between shock normal and upstream magnetic field (θ_{Bn}). The results of this analysis show that the highest fluxes of 300 keV electrons and 1 MeV protons are observed when the conditions $M_{A1} > 2.5$ and $50° \leq \theta_{Bn} \leq 75°$ are simultaneously fulfilled by the shocks. These investigations are supplemented by a computation of the first critical Alfven-Mach number for typical parameters of CIR related shocks.

3D MHD SIMULATION OF CORONAL MASS EJECTIONS

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A parallel adaptive mesh refinement (AMR) code for ideal magnetohydrodynamics (MHD) is used to investigate the generation, structure, and evolution of pressure-driven coronal mass ejections (CMEs) from the inner solar corona at 1 Rs out into inter-planetary space to distances exceeding 1 AU. The numerical algorithm is based on a MUSCL-type upwind finite-volume scheme and 8-wave Riemann solver flux function and a new massively parallel implementation of the method has been developed for a Cray T3E parallel computer having 512 processors. The pressure-driven CMEs are generated in inner solar corona, which is assumed to be a large rotating reservoir of hot magnetized plasma with an embedded multipole magnetic field. The results of the computations, including predicted changes in solar magnetic field and solar wind plasma flow properties produced by CME evolution, will be described.

THE ORIGIN OF THE 'MINIMUM' AND 'MAXIMUM' CORONA.

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The analysis of the some eclipse observations, showed: 1) A limiting case of a 'maximum' corona (for example, the eclipse of February 16, 1980) is observed in the events where the planes of portions of the streamer belt (or chain), wich follows a meridian, lie near the picture plane on both limbs, E and W simultaneously. 2) A limiting case of a 'minimum' corona occurs when the plane of the streamer belt (or chain) is perpendicular to the picture plane on both limbs simultaneously. The angle Θ_o of inclination of the streamer to the equator is determined by the latitude Θ, at which the portion of the belt under consideration is located. In the phase of minimum $\Theta_o \approx 0°$ (the eclipse of March 9, 1997), near maximum activity can reach $\pm(50° - 70°)$ (the eclipse of July 11, 1991).

ON THE STRUCTURE OF STREAMER BELTS.

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In an attempt to separate the temporal and spatial variations in polarization brightness (plasma density) along the coronal streamer belt, a study is made of the parts of the belt which are longitudenally aligned with the west or east limb of the Sun. It is shown that the brightness distribution along streamer belts is inhomogeneous with relative brightess variations $\approx 1.1 - 2.0$. Streamer belts consist of a sequence of coronal rays (streamers), each of which at distances $R > 3R_o$ from the solar center has a cross-section with a typical angular size of $\approx 10° - 70°$ along the belt and $\approx 10° - 30°$ across the belt with neighbouring rays separated by $L \approx 10° - 70°$. Examples from CR 1591 and CR 1592 show that, in the absence of CME influence, the distribution of streamer rays along the streamer belt can be stable for nearly two complete Carrington rotations.

OBSERVATION OF SOLAR AND GEOCORONAL LY-α

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On August 11, 1997 at 18.18 UT the payload GEOSOLLY was launched on board a BLACK BRANT IX rocket from White Sands Missile Range/USA and reached an apogee of about 330 km. The experiment GEOSOLLY consisted of a hydrogen cell containing molecular hydrogen at low pressure and was sealed by magnesium fluoride windows. A hot filament dissociated the molecules into hydrogen atoms, thus changing the absorption features of the cell on purpose. By measuring the scattered Ly-α photons with a sideways mounted detector, the core region of the Ly-α line could be studied. Another detector, positioned along the optical axis at the rear of the instrument, simultaneously measured the total intensity of the incident photons near 121.6 nm. By applying a switchable mirror in front of the cell both solar and geocoronal Ly-α fluxes could be examined. Results of the rocket flight will be presented and discussed.

EXTREME-ULTRAVIOLET DIAGNOSTICS OF PICK-UP IONS IN REGIONS CLOSE TO THE SOLAR CORONA.

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Recent investigations of pick-up ion data obtained with the AMPTE and Ulysses spacecraft resulted in the discovery that, in contrast to previous expectation, pick-up ion velocity distribution can be anisotropic. Such anisotropy implies a smaller efficiency of pitch-angle scattering than usually assumed and translates into a larger scattering mean free paths than previously attributed to these particles. We demonstrate that existing and upcoming *in-situ* observations can be supplemented with Earth-bound observations of ultra-violet resonance glow of pick-up ions in vicinity of the sun. The proposed observations, in combination with a theory of ions being picked-up by the heliospheric magnetic field close to the sun will not only allow us to obtain information about the anisotropy of the pick-up ion velocity distributions, but also to deepen our understanding of the physics of the accelerated solar wind and of pick-up ions in this innermost region of the heliosphere not yet well explored.

PHASE SPACE DIFFUSION AND ANISOTROPIC PICK-UP ION DISTRIBUTIONS IN THE SOLAR WIND.

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Pick-up ions are produced all over the heliosphere by ionization of neutral interstellar atoms. Over the last decade it was generally expected that after pick-up these ions are quickly isotropized in velocity space by strong pitch-angle scattering, though not assimilating to the thermodynamic state of solar wind ions. Recent studies of pick-up ion data obtained with AMPTE and ULYSSES have, however, revealed that during extended time periods substantially anisotropic distributions prevail. For a better understanding of the evolutionary fate of pick-up ions in phase space we present a pick-up ion injection study taking into account pitch-angle scattering, adiabatic cooling, drifts and energy diffusion. For an injection at 1 AU the resulting distribution function stays substantially anisotropic up to a distance of ~ 6 AU, unless strong isotropic turbulence levels of nondissipative spectra are considered. The bulk velocity of pick-up ions within this distance range turns out to be substantially smaller than the solar wind velocity. Pick-up ions are strongly spread out from that plasma parcel into which they were originally injected. Derivations of interstellar gas parameters from pick-up ion flux data thus have to be carried out with caution. As a consequence the location of the LISM helium cone axis and the LISM helium temperature are faked in the associated He^+ pick-up ion flux pattern.

ON CHARACTERISTICS OF THE HELIOSPHERIC PLASMA SHEET AT MINIMUM SOLAR ACTIVITY

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A technique is proposed for estimating the form and position of the boundary of extended horizontal parts of the heliospheric plasma sheet which separates this sheet from high speed solar wind streams from coronal holes. It is shown that the thicknes sof such portions of the HPS varies in different HPS in the range 6-47 degrees. Within the extended part of the HPS under consideration, its thickness can vary by a factor of 2-3. It is found that the thickness of the transition layer between extended parts of the HPS and solar wind streams from a coronal hole does not exceed 6 degrees. Solar wind parameter distrbutions have been obtained at $R = 1AU$ across the horizontal parts of the HPS undisturbed by the interaction with fast streams from coronal holes. It is found that the plasma flow velocity and the ion temperature both decrease from the HPS center to the periphery. The density and the magnetic field change little across the HPS.

COROTATING INTERACTION REGIONS: MAGNETIC FIELD BEHAVIOUR IN THE VICINITY OF STREAM INTERFACES AND HELIOSPHERIC CURRENT SHEET CROSSINGS

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During 1992 and 1993 the Ulysses spacecraft observed a long sequence of Corotating Interaction Regions (CIRs) produced by the interaction of high speed solar wind from the south polar coronal hole with slow speed wind from the near equatorial streamer belt. Stream interfaces in the CIRs separate the plasmas that originated in low speed solar wind and high speed solar wind at their source in the corona, while the heliospheric current sheet (HCS) separates magnetic fields of opposite polarity. In this paper we examine and classify the behaviour of the magnetic field in the vicinity of the HCS crossings and the stream interfaces during the above sequence of CIRs. A variety of HCS crossing signatures are found, some a clean discontinuity between the opposite polarities, others where the crossing is replaced by an apparent flux rope like signature. In some, but not all, cases we find clear magnetic field discontinuities also at the stream interface, although often these don't appear very different from other discontinuities elsewhere in the CIR. The results of this study are of importance in understanding which features within CIRs play a role in the modulation of energetic particle signatures.

RECENT HELIOSPHERIC MAGNETIC FIELD OBSERVATIONS AS ULYSSES APPROACHES APHELION

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After a highly successful exploration of the polar regions of the heliosphere in 1994 and 1995 during solar minimum activity, the ESA/NASA Ulysses spacecraft is now once again at near-ecliptic latitudes at a distance from the Sun of about 5AU. The equator was crossed in December 1997 and aphelion is in April 1998. In this paper we report on the recent results from the magnetic field investigation on Ulysses. The properties of the heliospheric magnetic field during the second slow latitude scan from the north pole down to the equator are described, in particular the radial component, underlying direction and variances of the field. At lower latitudes Ulysses is again observing heliospheric current sheet crossings and magnetic field compressions associated with corotating and transient solar wind flows. The pattern of current sheet crossings is discussed and related to the photospheric and coronal magnetic field patterns at the Sun. With the recent rise in solar activity, the number of transient signatures in the field data is increasing. We will report on any identifications of specific events with their solar origin and on whether we have been successful at observing any transient events at Ulysses also seen by near Earth spacecraft, for which the best opportunity will be the first months of 1998.

TEMPORAL VARIATION AND REDSHIFT OF HE I 584 Å IN SOLAR ACTIVE REGIONS

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Based on EUV observations of nine sunspot regions with the Coronal Diagnostic Spectrometer - CDS on SOHO we have studied spatial distribution, temporal variation and wavelength shift of the He I 584 Å line. The high spatial correlation between the coronal line Fe XVI 360 Å and He I 584 Å points to the coronal radiation as an important contributor to the formation of the He I line. Contribution to the line formation also from another source is suggested by the following two findings, which may be of value in future time dependent simulations of the He lines. We observe that the He I 584 Å line emission changes in minutes, significantly faster than the changes observed in the coronal radiation. The observed relative line-of-sight velocities scatter around a value that moves systematically towards the red as the peak intensity of the He I 584 Å increases from low to high values. The significance of the latter finding is supported by conditional probability calculations.

CENTER-TO-LIMB VARIATIONS OF THE CAII H AND K LINES IN SUNSPOT UMBRAE

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Amongst data on spectra of solar features, of particular interest is information about the center-to-limb intensity behaviour of Fraunhofer line profiles, especially in connection with the problem of construction of realistic atmospheric models. A comparison of theoretical and observed CaII H and K line profiles in sunspot umbrae has been made for different sunspot positions on the solar disk. Four semi-empirical static umbra models were used in calculations: the SUNSPOT model by Avrett (1981), Staude (1982), Maltby *et al.* (1986), and Severino, Gomez, and Caccin (1994). The models suggested by Avrett, Severino, Gomez, and Caccin, and Maltby *et al.* reproduce the center-to-limb evolution of the shape of observed profiles. The best agreement with profile parameters obtained from observations is given by the Severino, Gomez, and Caccin's model.

HIGH-SPEED SOLAR WIND STRUCTURE FROM ULYSSES RADIO MEASUREMENTS

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We analyse in-situ measurements of solar wind electron density and thermal temperature during Ulysses pole to pole fast transit near the 1996 sunspot minimum. The data are obtained with the radio receiver of the Unified Radio and Plasma wave experiment on Ulysses, using the method of quasi-thermal noise spectroscopy. This technique is based on the analysis of the electrostatic field spectrum produced by the thermal fluctuations of the ambient particles, which can be measured at the terminals of an electric antenna. It yields in particular accurate measurements of electron density and core temperature. Poleward of 40°, we deduce the radial profiles of these parameters in the steady-state fast solar wind coming from polar coronal holes. We also study the histograms of both parameters scaled to 1 AU; each distribution outlines a single class of flow which is well described by a normal distribution contrary to that obtained at low latitudes where different types of flows interact. Since Ulysses remained for a long time in the stationary polar solar wind, this gives the opportunity to measure in situ, for the first time, the spectrum of the electron density fluctuations at high latitudes.

CORRELATED C^+ AND O^+ SOURCE NEAR 0.2 AU

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From measurements with CELIAS/CTOF on SOHO, a wide range energy spectrum could be derived for each C^+ and O^+ singly charged ions in the solar wind. Despite their peculiar spectral shape they have been interpreted as a pickup population characterized by their very high anisotropy. Model fits assuming weak pitch-angle scattering with large mean-free-paths refer their origin to a position close to 0.2 AU. The actual value of anisotropy that is included as one of the fit parameters controls the resulting abundances, and the resulting drift speeds to an extent this is discussed in the presentation. As a further result properties of the source are framed with reference to the correlated modulation of both species.

INTERPLANETARY DISTURBANCES WITH FORWARD ROTATIONAL DISCONTINUITIES

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There are observational evidence in favour of interplanetary disturbances with forward rotational discontinuities. In this class of disturbances forward rotational discontinuities arrive to the Earth's orbit many hours before forward shock waves. These discontinuities switch on the geoeffective north-south Bz component of the interplanetary magnetic field and can be considered as predictors of forthcoming more strong interplanetary and geomagnetic disturbances at 1 AU. Solar sources of the disturbances are sudden disappearing filaments which interact with the heliospheric current sheet. These findings will be supported by observational evidence from historical and on-going solar and heliospheric missions, such as HELIOS, ISEE, PHOBOS, WIND etc.

A MULTISPECIES MULTIMOMENT MODEL FOR THE EXPANSION OF THE SOLAR WIND

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A new approach to study the expansion of the solar wind at the level of both the microscopic and the macroscopic states is presented. This model takes into account, as a first principle, the far from equilibrium state of the solar wind characterized by large heat flux in the electron and proton populations. Each step of the construction will be discussed: convergence properties, closure assumption and non-equilibrium collisional transfer properties. A first application of this model will be presented.

ESTIMATION OF ELASTIC $H-H$, $H-H^+$ COLLISION INFLUENCE ON THE INTERSTELLAR ATOM DISTRIBUTION IN THE HELIOSPHERIC INTERFACE

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Interstellar atoms cross the interface between the solar wind and the local interstellar cloud (heliospheric interface), and enter the heliosphere. Crossing the heliospheric interface interstellar atoms interact with the plasma component through charge exchange. The influence of charge exchange on the plasma parameters as well as on interstellar atom filtration has been studied extensively. Now the interest to elastic $H-H$, $H-H^+$ collision influence on the heliospheric H atom distribution is growing. Recently, Williams et al.(1997) on the basis of multi-fluid approach has shown that elastic $H-H$ collisions are crucial to determining the heliospheric H distribution.
In this paper we make estimations of the elastic $H-H, H-H^+$ collisions on the basis of a kinetic approach. It is shown that multi-fluid approach overestimates the effect of elastic collision influence.

INTERSTELLAR ATOM FILTRATION IN THE HELIOSPHERIC INTERFACE: INFERENCES ON THE LIC ELECTRON DENSITY

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The solar system is moving through the partially ionized local interstellar cloud (LIC). The ionized matter of the LIC interacts with the expanding solar wind forming the heliospheric interface. The neutral component (interstellar atoms) penetrates through the heliospheric interface into the heliosphere, where it is measured directly as pick-up ions, atoms, ACR's, ENA's or indirectly through resonant scattering of solar Ly- α. When crossing the heliospheric interface, interstellar atoms interact with the plasma component through charge exchange. This interaction leads to changes of both atom and plasma parameters. Using a kinetic model of the flow of the interstellar atoms, it is shown in the paper that the degree of filtration, the temperature and the velocity of the interstellar atom species depend on the interstellar proton number density. Comparing models computed for different interstellar proton densities with recent SWICS Ulysses pick up ion measurements, we constrain number densities of protons and H atoms in the Local Interstellar Cloud.

RAPID INVERSION OF HELIOSEISMIC TIME-DISTANCE DATA.

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Helioseismology is an area where geophysical methods have found application in solar physics and enabled investigation of the solar interior. In helioseismology the traditional approach has been to consider global oscillation modes of the entire sun, but in the last few years a new approach, called Time-Distance helioseismology, has emerged, where one considers local wave propagation on the sun. It has become possible to measure the traveltime between two points on the solar surface as a cross correlation function and thus produce solar seismograms which are very much like the seismogram considered in 'terrestrial' seismology. From these data it is possible to do a tomographic imaging of local structures in the outer part of the sun.
We have implemented a Multi-Channel Deconvolution inversion technique which yields a very rapid inversion. This technique has developed recently within geophysics for inversion of electromagnetic data. It is based on the Born approximation and speeds up the inversion by doing most of the calculations in the Fourier domain. The technique, which has been tested on data obtained from earthbound observations, will realise its full potential with high volume data sets from the MDI instrument on the SOHO satellite.

IS CIR ACCELERATION DEPENDENT ON HELIOGRAPHIC LATITUDE IN THE LIGHT OF ULYSSES DATA ?

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CIRs are formed by interacting fast and slow solar wind streams. A forward (FS) and a reverse (RS) shock forms typically at distances beyond 2 AU from the Sun. The FS propagates equatorward, the RS poleward. Both shocks are capable of accelerating ions to MeV/N energies, the RS being more efficient. Also, electrons are accelerated at the RS, but in general not at the FS. ULYSSES has encountered on its pass to the Sun's south polar region and on its pass from its north polar region more than 35 increases in the energetic particle fluxes, while it moved in distance from 5.3 to 2 and back, however, at the same time also in latitude from 0° to 80° heliolatitude. Therefore it is not possible to decide whether latitude or radial distance determines the peak flux of the energetic particles. We compare ULYSSES results with measurements from PIONEER-10/11 and VOYAGER obtained in the ecliptic plane to conclude that the efficiency of particle acceleration is largest in 3-5 AU and not latitude dependent, but becomes dependent on latitude due to the more complicated structure of the interplanetary magnetic field when the shocks no longer reach the S/C and particles propagate along the field towards the Sun.

CA, SI, AND FE ELEMENTAL ABUNDANCES IN THE SLOW AND COLD SOLAR WIND DETERMINED FROM THE MASS INSTRUMENT ON WIND

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Measurement of the chemical elemental abundances in the solar wind is important for studying processes in the solar wind source region, i.e. the place in the chromosphere and the corona from where the solar wind flow originates. We present results of the elemental abundances of Ca, Si and Fe as obtained with the MASS instrument aboard the WIND spacecraft in periods of slow and cold solar wind. These elements are of particular interest because they all have a low first ionization potential ($\leq$ 10eV). We compare the Ca (FIP: 6.11 V) abundance with the abundances of Si (FIP: 8.15 V) and Fe (FIP: 7.9 V) in order to test if Ca exhibits the expected behaviour of the low FIP elements, or behaves differently as a very low FIP element as has been suggested by other studies. When possible we also determine the freeze-in temperature of Ca from its most abundant charge states i.e. Ca^{10+}, Ca^{11+} and Ca^{12+}. These results will serve as a clue concerning the vertical temperature structure in the corona and will complement the present results obtained so far from C, O, Si, S, and Fe.

SUPRATHERMAL SOLAR WIND AND PICKUP IONS MEASURED BY THE WIND/SMS-EXPERIMENT NEAR THE LIBRATION POINT L1

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The WIND S/C performs elliptical orbits around the Earth and reaches for limited time intervals the libration point L1 due to a deflection by the gravitational field of the moon. Ions of 0.5 - 225 keV/e can be measured by the SMS experiment. The masses ($1 < m < 45$ amu), the energy spectra and the angular distribution of such ions will be determined. Our study deals especially with singly charged pickup ions which result from interstellar neutral atoms entering the solar system and becoming ionized by the solar UV light as well as pickup ions released from interplanetary dust particles. The velocity distribution, angular distribution and charge state of the measured ions helps to distinguish between ions of solar and magnetospheric origin. The measurements are discussed in relation to earlier results of other authors.

REMOTE SENSING OF THE SOLAR WIND BY SWAN/SOHO LYMAN α MEASUREMENTS

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The SWAN instrument on board the SOHO spacecraft has now measured Lyman α all sky maps already more than two years. A preliminary investigation of the maps measured in 1996 showed that the solar wind mass flux seems to be nearly flat for all solar latitudes outside the equatorial region from $-20°$ to $20°$. In this central region the mass flux shows a prominent increase. This result is very similar to the one obtained from the Lyman alpha measurements by the Prognoz satellites in 1976-7 and to the one from in situ measurements by the Ulysses spacecraft. In this paper we present a more refined estimation of the solar wind mass flux distribution from SWAN data. We use now lines of sight only to star void regions in the sky which eliminates the contamination of results with high UV fluxes from hot stars. In addition to photometric measurements we employ also spectral measurements by SWAN in order to determine the interstellar gas parameters which leads to a more accurate determination of the solar wind mass flux distribution.

ULYSSES AND WIND OBSERVATIONS OF THE TRANSIENT PARTICLE EVENTS IN NOVEMBER 1997

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In this presentation we describe the main features of the transient solar energetic particle events observed by the Ulysses and WIND spacecraft during the first half of November 1997. The sequence of solar activities on November 4 and 6 are identified as the solar origin of the intense particle events measured at two different locations in the heliosphere. Ulysses was in the ecliptic plane at 5.34 AU from the Sun and at ~100° west in heliolongitude from Earth, while WIND was near the Earth at 0.99 AU in the same plane. The nature of the energetic particle transport and of the propagating structures arriving at the spacecraft locations allows us to explain the differences and similarities between the particle intensities and plasma observations at WIND and Ulysses spacecraft.

MODELLING OF SUNSPOT EQUILIBRIAE FOR FINITE FLUX TUBE DIAMETERS

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The dispersion equation of magnetoacoustic-gravity waves in sunspot regions strongly depends on the gradients of the magnetic field in the magnetohydrodynamic equilibrium. Thus, as up to now for sunspot pulsations only models with infinitesimal thin flux tubes exist, here a sunspot model with finite flux tube diameter, and attitudinal as well as horizontal magnetic field gradients is developed. The magnetohydrodynamic equilibrium of circular symmetric H-spots is numerically studied. Thereby, the amplitude of the magnetic field was described by the interpolation formula $H(\rho, z) = H_0(z)/(\Lambda + \rho^2)$, where ρ is the horizontal distance from the symmetry axis showing in z-direction. $H_0(z)$ is the magnetic field on the symmetry axis, which is found using the simple Schlüter–Temesváry condition of geometric similarity of magnetic flux distribution.

INTERSECTION OF HELIOSPHERIC CURRENT SHEET WITH FORWARD SHOCK OF COROTATING INTERACTION REGION

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Heliospheric magnetic field lines can intersect with shock waves. where they are refracted towards the shock. The heliospheric current sheet (HCS), the boundary between regions of opposite polarisation of the magnetic field, is by definition bounded by magnetic field lines. The times of HCS and forward shock (FS) observations by the Ulysses spacecraft during several successive solar rotations show a very regular behavior. The conclusion is drawn, that an FS/HCS intersection structure was present in the heliosphere. In addition, an attempt is made to identify those energetic particles, which were accelerated at the FS and then travelled to Ulysses along the HCS perpendicular to the magnetic field.

COSMIC RAY DIFFUSION IN THE STRONG LARGE-SCALE RANDOM AND REGULAR MAGNETIC FIELDS

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The nonlinear small-scale collision integral is averaged over the larmor rotation of a particle in regular field with allowance for all cyclotron harmonics.The kinetic equation with the nonlinear collision integral is solved in the case of strong regular magnetic field.The mean free path of a particle along the regular magnetic field L is found.In the case $L_0 << R$,L is proportional $R*R/R_0^n$,where L_0-correlation length,R- gyroradius in the random field,R_0-gyroradius in the regular field,n-spectral index of the correlation function.In the case $R << L_0$, L=a*R, where a-same function of the order 1.

DIRECT OBSERVATION OF LUNAR PICK-UP IONS WITH WIND-STICS

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Planetary pick-up ions are an ideal diagnostic tool to remote sense the surface composition of the parent body from which they originate. We report and discuss the direct observation of heavy pick-up ions which are detected during several lunar fly-bys with the Supra-Thermal Ion Composition Spectrometer (STICS) on the WIND spacecraft. The STICS experiment with an energy/charge range from 6 to 223 keV/e is in an ideal position to determine the mass/charge and mass of individual ions therby allowing a direct identification of the observed ions.

ELECTRON TEMPERATURE IN THE SOLAR WIND FROM KINETIC MODELS

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We calculate analytically the radial temperature profile for the solar wind electrons at large heliocentric distances, using a kinetic collisionless model with an arbitrary electron velocity distribution in the corona. We concentrate on the total temperature since collisionless models are more adapted to calculate this temperature than the parallel or perpendicular temperatures separately. The electron temperature profile has a generic form which is the sum of a term decreasing as $r^{-4/3}$ plus a constant term, with both terms having the same order of magnitude near $r \sim 1$ AU. This result is virtually independent on the particle velocity distributions in the corona. The $r^{-4/3}$ term comes from the electrons trapped in the heliospheric ambipolar electric potential; the constant term comes from the electrons having enough energy to escape. This calculation thus predicts a total electron temperature profile which varies roughly midway between isothermal and adiabatic (isotropic) behavior near 1 AU, as is generally observed. The electron temperature profile flattens with increasing heliocentric distance; it also flattens as the exospheric radius decreases and is thus flatter in the high-speed wind. We compare these results with observations made on Ulysses in the polar high-speed wind.

Interplanetary scintillation measurements of the large scale structure of the heliospheric magnetic field using EISCAT.

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Extended observations of interplanetary scintillation of the signals from quasars, using two spaced antennas of the EISCAT facility, have indicated the direction of the baseline between the two antennas at which maximum correlation is observed. From this it is possible to determine the direction of flow of the high latitude solar wind in the meridional plane at distances from the sun between 20 and 100 solar radii. In all cases where signal strength is sufficient for this measurement to be made with sufficient accuracy, the analysis shows there to be a small but significant non-radial component present. Owing to the high magnetic Reynolds number of the plasma, the direction of flow of the solar wind in the meridional plane must also indicate the direction of the magnetic field averaged over the line-of-sight of the signals. We present results from our most recent observations and discuss the possible implications for the large scale structure of the heliospheric magnetic field.

NONLINEAR FAST MAGNETOHYDRODYNAMIC WAVES IN SOLAR CORONAL HOLES

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A coronal hole is modeled as a slab of cold plasma threaded by a vertical, uniform magnetic field. A periodic driver acting at the coronal base is assumed to drive the velocity component normal to the equilibrium magnetic field. Previous works indicate that, in the linear regime, only fast mode perturbations propagate, since Alfvén waves are excluded from the model. However, in this work it is shown that nonlinear terms in the magnetohydrodynamic (MHD) equations give rise to excitation of the velocity component parallel to the equilibrium **B**, with a lower amplitude than the normal component.
Another consequence of nonlinearities is the generation of higher-frequency Fourier modes, which can be detected by Fourier analyzing the velocity variations above the photosphere. The nature of the nonlinear interactions in the MHD equations determines the frequency of those modes. These interactions are quadratic in the case of the parallel component, while they are cubic in the case of the normal component. Therefore, nonlinearly excited frequencies $2\omega_d$, $4\omega_d$, $6\omega_d$, ... are present in the parallel velocity, whereas frequencies $3\omega_d$, $5\omega_d$, $7\omega_d$, ... are present in the normal velocity, with ω_d the driving frequency.

PROPAGATION OF THREE-DIMENSIONAL ALFVÉN WAVES IN THE HIGH SPEED SOLAR WIND: EFFECTS ON THE LYα, LYβ AND O VI LINES OBSERVED BY UVCS/SOHO

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We investigate the effects of three-dimensional Alfvén waves propagation in the solar wind on the Lyα, Lyβ and O VI (1032 Å and 1037 Å) lines observed with UVCS on board SOHO. To this end, we use a detailed model of solar wind which takes into account relevant physical effects, including gravity stratification, thermal conduction, radiative losses, plasma heating (via a phenomenological term), and the momentum deposition by a spectrum of non-WKB Alfvén waves. We synthesize the emission in Lyα, Lyβ and O VI (1032 Å and 1037 Å) lines considering wind models on a grid of realistic parameter values.

UVCS/SOHO OBSERVATIONS OF THE POLAR HIGH SPEED SOLAR WIND

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We have dedicated a week-long observing campaign with the instruments on board SOHO to study the north polar coronal hole of the Sun and the wind originating from it. The scope of this campaign is to set up an observational scenario describing the conditions of the solar wind from its origin to high heliocentric distances. To this end we observed simultaneously the inner corona with EIT, CDS, and SUMER and the outer corona with UVCS, the latter being the workhorse of the present project. We present here the first results of the analysis of the UVCS observations in the Lyα and O VI (1032 Å and 1037 Å) lines in the range of heliospheric distance from 1.5 $R_\odot$ to 3.5 $R_\odot$.

HISTORY OF THE SUN-AS-STAR MAGNETIC FIELD EVOLUTION INFERRED FROM DIRECT AND INDIRECT OBSERVATIONS

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Magnetic field viewed as Star has been observing since 1968. To infer the Sun-as-Star magnetic field long before the period observed, a restorable technique was applied to Hα photographs and geomagnetic activity variations available beginning the last century. For this purpose, synoptic charts of the large-scale filament distribution have been used to establish close associations between the Sun-as-star magnetic field just inferred and directly observed. Close correlations found were then used to restore a Sun-as-star magnetic field structure and evolution in late of 50s and 60s, when the solar magnetic field was never being observed. Stackplot display of inferred data revealed a large-scale magnetic field organization during a course of solar cycle. Patterns in the Sun-as-star distribution inferred in late of solar cycles 19 and 20 were compared with those obtained for solar cycles 21 and 22. Long-lived systems in longitude magnetic field organization were persisted throughout solar cycles 19-22. A sector structure of the solar magnetic field restored in the past was compared also with Svalgaard interplanetary magnetic field sector structure inferred from geomagnetic field observations. New features in the large-scale organization and evolution of magnetic field on the Sun were obtained and discussed.

INTERSTELLAR NEUTRAL HYDROGEN VELOCITY AND TEMPERATURE FROM SWAN/SOHO HYDROGEN CELL MEASUREMENTS

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The SWAN instrument on board SOHO has measured in all directions, and for a large number of locations of the spacecraft along its solar orbit, the absorption by a Hydrogen cell of the Lyman α interstellar glow. These spectroscopic measurements have been used to derive the characteristics of the interstellar hydrogen flow in the inner heliosphere. Conclusions can be drawn on the effect of the heliospheric interface on the neutral hydrogen, by comparison with the properties of the helium flow and those of the local interstellar cloud surrounding the Sun.

REMOTE RADIO TRACKING OF CMEs

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Coronal and interplanetary shocks associated with CMEs often generate type II radio emissions at hectometric and kilometric wavelengths. Wind and Ulysses have detected these radio emissions at radio frequencies from 20 kHz to 14 MHz. Such radio observations provide a means of remotely tracking CMEs from the solar corona, in the range of the SOHO coronographs, out to 1 AU and beyond. The study of the interplanetary transport of CMEs is important for predicting the terrestrial impact of CMEs. It is well known that CMEs with associate shocks are more geoeffective than those without shocks. Thus CMEs with associated radio emissions are more likely to be geoeffective than those without radio emissions. We have developed new analysis techniques that inherently reveal the dynamics of a CME as it propagates through the interplanetary medium. These techniques permit us to identify the solar origin of a CME, predict the time of arrival at Earth, determine whether the type II radio emissions occur at the fundamental and/or harmonic of the plasma frequency upstream or downstream of the CME driven shock and determine where along the shock front the emission occurs.

THE DYNAMICS OF INTERPLANETARY DUST PARTICLES CLOSE TO THE SUN: THE PLASMA–POYNTING–ROBERTSON EFFECTS OF THE SOLAR WIND NEAR THE CORONA

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The orbits of zodiacal $1-10\mu$ dust grains near the solar corona are substantially influenced by the plasma–Poynting–Roberston force, which is governed by the thermodynamical structure of the solar wind near the corona. Because of the strong spatial variations of the density, temperature and Mach number, the local drag coefficient also shows a strong variability. Opposite to the far solar wind, where the drag coefficient is constant, the drag coefficient at distances less than 0.3 AU strongly depends on the spatial coordinates. In this region also the three-dimensional structure of the solar wind leads to an interesting latitudinal influence of the solar wind to the orbits of the dust particles and the resulting number density of the zodiacal grains. We will present first results and discuss the consequences for the radial drift of dust grains and their size distribution close to the Sun.

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SOLAR CYCLE-INDUCED MODULATIONS OF THE INTERPLANETARY PICKUP ION FLUXES

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In the paper we present results of the modelling of the expected solar cycle-induced modulation of the production rates and the resulting fluxes for several most abundant pickup species in the interplanetary space (H^+, He^+, O^+, Ne^+). This modelling is focused mainly on the inner part of the solar system ($R < 5$ AU) with special stress on observations performed from 1 AU and along the Ulysses flight-path. Adopting realistic courses of the variabilities of the photoionization and charge-exchange rates during the period 1974–1994 for different neutral interstellar species, we model the time-variations of their distribution in the inner heliosphere, as well as the variations of the corresponding pickup ion fluxes. It is shown for the considered pickup ions that essentially only the He^+ flux variations are correlated with the solar activity, and for the other species (especially those with lower ionization potential, as H and O) one may expect the opposite behaviour. In particular, we demonstrate that in the case of H^+ pickup ions a part of the expected flux variabilities, most pronounced in the downwind region, may be caused not only by the time-varying ionization effects, but also by the variation of the solar Lyman-α radiation pressure, which significantly affects the local distribution of the neutral H atoms in the inner regions of the heliosphere. We also show that while at small heliocentric distances ($R < 3$ AU) the maximum of the H^+ and O^+ pickup fluxes is expected around the upwind axis. the He^+ and Ne^+ form the characteristic 'cone' structure with significantly enhanced flux in the downwind region.

SHORT VARIABILITY OF THE SOLAR WIND PARAMETER

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The variations of the solar wind parameter, like velocity and density, become more important in astrophysical observations (e.g. Scherer et al. 1997). Here we study the short-term variations of the solar wind plasma parameters obtained from the spacecraft Helios 1/2, OMNI, Pioneer 10/11, Ulysses und Voyager 1/2. On all spacecraft we observe variations in density and velocity with periods of 25.3 days and 13.3 days, which are connected with the solar rotation and the tit; of the magnetic equator with respect to the ecliptic. In addition both periods vary with the solar cycle. Here we will discuss these variations as well as their influence to astrophysical observations (pulsars, etc.).

COMPARISON OF THE COSMIC RAY FLUXES MEASURED ONBOARD OF PIONEER 10 AND PIONEER 11

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The Pioneer 10 and Pioneer 11 spacecraft are presently located at heliocentric distances of ~ 67 AU in the downwind and ~ 50 AU in the upwind direction of the local interstellar medium. Therefore, the spacecraft have probed different regions of the heliosphere. Since the Charged Particle Instruments (CPI). the Trapped Radiation Detectors (TRD) and Geiger Tube Telescopes (GTT) are almost identical, the corresponding measurements before 1992 (the end of the Pioneer 11 mission) are uniquely suited to compare the cosmic ray fluxes in the upwind (Pioneer 11) and the downwind heliosphere (Pioneer 10). We will present first results obtained with a new anlaysis of data obtained by these TRD–, CPI–, and GTT–instruments.

LONGTERM VARIABILITY OF THE SOLAR WIND PARAMETERS

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In the solar wind parameters (i.e. density and velocity) periodic variations of 400 days (Richardson et al., 1994) have been observed. We analyse the power spectrum of the time variations of the plasma parameters with the data from the spacecraft Helios 1/2, OMNI, Pioneer 10/11, Ulysses and Voyager 1/2. The time series from these spacecraft are even long enough to resolve the solar cycle variation (11 years), and hence allow us to study the quasi–1–year periods. This longterm variability is not yet well understood. We will present first results and discuss possible connections with the solar rotation and the solar cycle variations.

THE INFLUENCE OF THE NEUTRAL GAS DRAG IN THE OUTERHELIOSPHERE

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In the outer heliosphere the density of the incoming neutral gas becomes larger than the solar wind density. Therefore, the drag force acting on dust particles is dominated by the neutral gas drag, which is similar to the plasma Poynting-Robertson effect. The main difference is that opposite to the radial plasma Poynting-Robertson force the neutral gas drag acts along the flow direction of the interstellar medium. It can be shown, that this effect even dominates at solar distance of 20 AU the evolution dust particles, with spherical diameters larger than 10 micrometer. In the region of the Edgeworth-Kuiperbelt the dust particle migrates to eccentricities close to 1 in less than $< 10^6$ years. Therefore. the outer heliosphere should be almost a dust free region. The semi-analytical solutions of the perturbation equations will be presented and the influence of the neutral gas to the heliosphere and to protoplanetary disk will be discussed.

THE CONNECTION OF THE FAST SOLAR WIND TO THE CHROMOSPHERIC NETWORK PATTERN

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We analyze how the fast solar wind originates from the chromospheric network pattern through magnetic funnels located at the boundaries of the network. At the feet of these funnels are located thin ionizing layers in which the ionization is predominantly created by electron impact collisions but in the lower regions of these layers photoionization by EUV photons can become important.
Provided the downward electron heat flux is sufficiently great the flow in the funnel remains subsonic throughout, otherwise it becomes choked or exhibits a critical supersonic-subsonic transition. For temperatures appropriate to the lower corona and chromosphere, and with reasonable temperature gradients the layer is situated at about 700 km below the coronal base and the density is around $4 \cdot 10^{10}$. We also discuss the absence of a FIP effect and the possibility of helium depletion.

ULYSSES OBSERVATIONS OF A PAIR OF SLOW MODE SHOCKS INSIDE A CORONAL MASS EJECTION

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From February 3-5 1995, as Ulysses was approaching the ecliptic at 24 ° S latitude, it was intercepted by the first CME that had been seen in many months. The CME was of the "over-expansion" type seen previously at high latitudes and was accompanied by energetic ions and electrons. The magnetic field and plasma measurements revealed a signature within the CME similar to that first seen in the Earth's distant magnetotail by ISEE-3. The latter signature has been identified as a pair of slow mode shocks bounding a region (plasmasheet) containing reconnected field lines. Analysis of the Ulysses data has confirmed that a pair of slow mode shocks are present at the boundaries of this structure. In addition, a current sheet, across which the field reverses direction, has been found to lie between the shocks. The energetic particles appear to be affected by these discontinuties.The existence of this complex structure inside a CME is striking , not having been reported previously. It suggests magnetic reconnection within the CME at an x-type neutral point, evidence of which has proven elusive in the past.

TEMPORAL VARIATIONS OF INTERPLANETARY LYMAN α RADIATION MEASURED BY SWAN

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A SWAN (Solar Wind ANisotropies onboard SOHO (SOlar Heliospheric Observatory) satellite has measured interplanetary Lyman α intensity since December 1995. Solar Lyman α radiation is scattered by hydrogen atoms which move through the solar system 4-5 AU/year. SWAN measures the interplanetary Lyman α radiation at 1 AU from all directions of the sky. Approximately three fullsky maps of interplanetary Lyman α intensity are observed in a week. The data measured during these two years are used to study temporal variations of solar Lyman α radiation.

CME SHOCKS AND THEIR IDENTIFICATION IN LASCO DATA

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Formation of shock waves in front of expanding magnetic structures. such as loops and arches, is predicted by theoretical models of coronal mass ejections (CME). These shock waves have been detected in the solar wind at large distances from the Sun. However, their observation at short distances in the solar corona has been difficult. The structure of the shocks is determined by processes of turbulent momentum and energy transport in the coronal plasma. Our numerical simulation show that the shock front is not distinctively sharp. and thus is not necessarily associated with sharp features in CME images. We have attempted to identify the shocks in the LASCO data by comparing the radial intensity profiles in limb CME with the theoretical model (Stepanova. T.V. and Kosovichev, A.G., 1993, *Space Sci. Rev.*, **70**, 171). We demonstrate that the shocks can be identified at least in some cases of CME of the simple loop-like structure. The LASCO observations give evidence for turbulent flows associated with the shocks. We have determined the speed of the shocks and expanding loops and compared with our model.

SOLAR WIND AND IMF PARAMETERS AT THE EARTH'S ORBIT DURING THREE SOLAR CYCLES

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We have used the solar wind and IMF NSSDC OMNIWeb data set (1964-1996) to study long-term variations. Data base contains about 250 000 hourly averaged values of the solar wind velocity, density, temperature and magnetic field strength and vector components. Three-monthly running averaged values of all these parameters. as well as solar and geomagnetic indexes were calculated and intercompared during different phases of the 20, 21 and 22-d solar cycles. General trends and solar cycle variations are evaluated and compared with published results. Points of correspondence and differences are noticed. New features in the density and the temperature are found. Mass, momentum. energy and enthalpy flux densities; thermal. dynamic and magnetic pressures: plasma beta; Alfven speed, adiabatic sound speed; sonic Mach. Alfven - Mach and magnetosonic Mach numbers also show specific variations. Possible interpretations are suggested using the concepts of the magneticaly open. closed and intermittent types of the solar wind sources. We conclude that the observed variations at the Earth's orbit are related to the space-time evolution of the mentioned sources on the Sun and their different proportions during different solar cycle phases. Magnetic fields of the Sun and the heliospheric current sheet play the mediating role.

FORCING OF DIFFERENTIAL ROTATION AT THE INTERFACE BETWEEN THE CONVECTIVELY STABLE AND UNSTABLE LAYERS

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A model of the region near the interface between solar convection and radiative zones is suggested. The essential feature of the model is the consideration of the deformation of the interface between convectively stable and unstable parts of the layer which appears to be due to the influence of large-scale flows on the conditions in this region. Two-dimensional numerical simulations show that one of the consequences of the interface deformation is the appearance of latitudinal gradient in temperature distribution which gives rise to strong vertical gradients in angular velocity in the vicinity of the interface. Such differential rotation is, in fact, the thermal wind like in the Earth's atmosphere. The other consequence of the deformation of the interface is the forcing of differential rotation. It is found that the pumping mechanism is similar to the deformational long-wave instability mechanism that operates in the rotating fluid layer heated from below with a deformable upper stress-free surface. Nonlinear effects lead to the limitation on the amplitude of the differential rotation and to the establishment of the stationary pattern. Stationary differential rotation is in qualitative agreement with the recent results obtained by helioseismology.

SOLAR WIND STREAM INTERFACES IN COROTATING INTERACTION REGIONS: SWICS/ULYSSES RESULTS II

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Motivated by the well-known differences in charge - state and even elemental composition of the slow solar wind as compared to high-speed streams, we have analyzed observations made by the Solar Wind Ion Composition Spectrometer (SWICS)/Ulysses mass spectrometer of the series of corotating interaction regions (CIRs) encountered by Ulysses in 1997/1998 at 4.5 - 5.4 AU from the Sun. We identify stream interfaces within each CIR by their kinetic and compositional signatures as described in *Wimmer-Schweingruber et al.* [*JGR*, , **102**, (1997), 17407 – 17417] for the stream interfaces observed in 1992/1993, and give an update on those observed in the time period mentioned above.

SH5

METHODS FOR A COMPLETE IDEAL MHD STABILITY STUDY OF 1D LINE-TIED CORONAL LOOPS

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A procedure is introduced to perform a complete ideal MHD stability analysis of one-dimensional cylindrical equilibrium models for coronal loops, including the important effect of line-tying. The stability is completely determined by calculating the critical (marginally stable) length for the onset of ideal MHD instabilities for every azimuthal wave number m. The analysis consists of the combination of WKB methods to determine the critical length of intermediate to high (infinite) values of m with a numerical code (using bicubic finite elements) for the low to intermediate values of m. It is found that for sufficiently large m the critical length can be expressed as $l_c = l_0 + l_1/m$ for non-force-free fields and as $l_c = ml_0 + l_2/m$ for sheared force-free fields. It is also demonstrated that in general either the $m = 1$ or the $m \to \infty$ mode has the shortest critical length, the former being the first to become unstable for nearly force-free magnetic fields, the latter for strongly non-force-free fields. Therefore, a stability analysis of these two modes will normally suffice, with perhaps a need for some more numerical calculations near the point where the modes cross over. The combination of these two tools provides a complete stability assessment.

SUPRATHERMAL SOLAR PARTICLES IN LUNAR SOILS - A COMPARISON WITH LONG - TIME FLUX AVERAGES INFERRED FROM SPACECRAFT MEASUREMENTS

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Trapped gases in lunar soils contain a low-energy component which is generally ascribed to implanted solar wind particles and a second, "high-energy" component, with a different isotopic signature which is attributed to "solar energetic particles" or suprathermal particles. The more energetic component amounts to tens of percent of the total trapped solar noble gas content. Even though partial loss of the shallowly implanted solar wind particles can lead to a relative enrichment of higher energy particles, the data apparently require a flux of suprathermal particles orders of magnitude bigger than expected from a comparison with a typical energy distribution as observed with spacecraftborne instruments.
We have begun to establish a database of published energy and velocity spectra of suprathermal particles and derive a long-time flux average. We discuss this long-term average flux in relation to the appearance of corrotating interaction regions in the inner solar system. We speculate about the frequency of such events during the history of the lunar regolith.

ESTIMATES OF SCALE SIZE OF IRREGULARITIES IN THE FAST AND SLOW SOLAR WIND USING EISCAT OBSERVATIONS OF INTERPLANETARY SCINTILLATION.

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The variation of the maximum correlation coefficient between scintillations (IPS) observed by two EISCAT antennas according to their radial and transverse separation depends on the actual scale of the irregularities. Analysis of the power spectra of IPS measurements of the solar wind using the EISCAT system yields a definite high-frequency cut-off which varies with heliocentric distance. This cutoff can be interpreted in terms of the scale size of irregularities in the solar wind by using bi-static measurements of the solar wind velocity. The analysis of scintillation in terms of the scale of irregularities is discussed, including possible reasons for the significant differences and similarities between the fast and slow solar wind.

INVESTIGATION OF COSMIC RAY VARIATIONS BY THE MULTI-CHANNEL REGISTRATION IN THE DIFFERENT ENERGETIC RANGES

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The integral equation system is worked out on a basis of the ground multichannel registration of the cosmic ray intensity in several energetic ranges. It is shown that solution of integral equation system describing the temporal cosmic ray variations allows to separate the observed variations to the different origin components. Solution of the equation system allows to find the parameters of cosmic ray primary spectrum, the changes of geomagnetic cut-off rigidity, also the changes of the atmospheric pressure and the averaged temperature through the atmosphere.

DO ALL SOLAR ATMOSPHERE AREAS PROVIDE EQUAL SOLAR WIND KINETIC ENERGY FLUX ?

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Analysis of solar wind data obtained on the Prognoz 7 satellite allowed for selecting different types of solar wind streams and comparing bulk parameters in different types of streams (Yermolaev, ASP Conf.Ser., 95, 288, 1996; Yermolaev and Stupin, JGR, 102, 2125, 1997). These data show that (1) processes of proton and alpha acceleration are similar in the heliospheric current sheet (HCS) and streams from coronal streamers (CS) and they differ from ones in the streams from coronal holes (CH), (2) average kinetic energy flux of ions E_k in HCS and CS is very closed to E_k in CH, and (3) the Sun's loss of ion kinetic energy in HCS and CS is equal to one in CH. These relations allow us to suggest a hypothesis that mechanisms of solar wind formation provide the equality of E_k in different large scale structures in the solar atmosphere, the coronal mass ejections being caused by E_k deficit in a solar wind stream (or by excess of energy in a solar corona area being responsible for this stream). The hypothesis should be tested by solar wind measurements at different heliolatitudes because only small number of CH may be studied near ecliptic plane.

ST6 Nonlinear dynamics in the heliosphere (co-sponsored by NP)

Convener: Macek, W.M.
Co-Conveners: Carbone, V.; Grappin, R.

MAGNETOHYDRODYNAMIC SOLITARY WAVES: RELEVANCE TO SOLAR WIND OBSERVATIONS

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Inclusion of Hall current and/or finite Larmor radius (FLR) corrections introduce dispersion into the standard ideal MHD theory and provides the existence of solitary MHD waves. Unlike most of the studies on solitons in collision-free plasmas, which are based on weakly non-linear, time-dependent, evolution equations (KdV, DNLS), we start from the fully non-linear basic system and isolate solitary waves from the family of 1D stationary waves with the help of the fixed-point analysis. Spatial structures are presented and the strong influence of the plasma thermodynamics is pointed out. Relevance of these solitons to solar wind observations (magnetic holes, interplanetary field enhancements) is suggested.

SPACE – TIME DYNAMICS MODELING OF INTENSIVE ALFVEN WAVE COLLISION IN SOLAR WIND PLASMA

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Space-time collision dynamics of intensive Alfven waves in Solar wind plasma is analyzed on the basis of the magnetohydrodynamic conception. For this purpose a special computer program realizing MHD equations in one-scale approximation and making possible to carry out calculating experiments in dialog regime was used. In numerical experiments Alfven wave transformation into magnetic sound and the influence of given disturbances scales correlation on result of their interaction were studied. Simulation confirms phenomenon of reflection from the regions of abrupt parameters' change, which are sensitive to space scales of interacting objects. Obtained results are the illustration of the intensive Alfven wave interaction process, carrying the high level of magnetosound disturbance in Solar wind.

ALFVÉN WAVE COLLAPSE IN THE SMALL-DISPERSION LIMIT

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Dispersive Alfvén wave trains propagating along an ambient magnetic field are circularly polarized and their envelope obeys the scalar nonlinear Schrödinger equation, with possible coupling to magnetosonic waves. According to the β of the plasma. convective or absolute modulational instabilities with respect to transverse perturbations lead to Alfvén wave filamentation with possible formation of sharp acoustic fronts.
For weak dispersion, this collapse proceeds with a roughly circular polarization, up to a critical transverse scale $l_\perp$ such that $\frac{l_\perp}{\lambda} \approx (\frac{l_d}{\lambda})^{-1/2}(\frac{\delta B}{B_0})^{-1}$ where l_d measures the characteristic dispersive length, λ the Alfvén wavelength and $\frac{\delta B}{B_0}$ the relative amplitude. The wave then ceases to be circularly polarized and its amplitude saturates. In this regime, the envelope dynamics is governed by a vector nonlinear Schrödinger equation with anisotropic diffraction. Small scales are still formed but instead of foci, very strong gradients develop on elongated structures.

SCALING GYROSCOPE CASCADE MODELS AND THE MULTIFRACTAL MHD INTERMITTENCY.

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Hydrodynamics intermittency has been often investigated with the help of some simplified caricatures of Navier-Stokes equations. Well-known examples are the Burgers equation and shell-models.
Since the spatial dimension is absent in shell-models, whereas it is crucial for the development of intermittency, a more complete model was needed. For hydrodynamics, we developed such a model - the Scaling Gyroscope Cascade (SGC),- by keeping only certain type of interactions of the Navier-Stokes equations. In order to take into account the spatial dimension, while keeping an exponential discretization of scales, we introduce a tree-structure of eddies. Along this tree-structure the equations of evolution due to direct interactions between eddies and sub-eddies are analogous to the Euler equations of a gyroscope. The corresponding indirect interactions are obtained by coupling an infinite hierarchy of gyroscopes.
We present a simple and natural extension of the SGC to the MHD case. Based on the considerations of the structure of the full system of equations, the MHD SGC could be interpreted as a result of superposition of two similar type cascades. We show the relevance of the SGC models for an investigation of multifractal MHD intermittency and transitions to Self Organized Criticality for extreme events.

MIXING OF THE HELIOSPHERIC MAGNETIC FIELD LINES

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The nature of the fluctuation of the heliospheric magnetic field is investigated based on Ulysses observations. A novel method, the spinor formalism is applied to discern between various types of inhomogenities. Among those. the separation rate of the adjacent magnetic field lines is studied in detail, including its dependence on the spatial scale of the inhomogenities. It is argued that the separation leads to the mixing of field lines, which is an important constituent of the cross-field diffusion of energetic particles.

SHOCKS AND ANTISHOCKS IN THE MHD–THOMAS MODEL

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We study the fronts in the 1–D Thomas model of MHD at large magnetic Prandtl number. In a preliminary numerical study, Passot observed a shock configuration, reminiscent of the *th* profile of the stationary Burgers shock. Prompted by this finding, we solved exactly the stationary case at infinite Prandtl number; four families of solutions are relevant in the physical context; they exhibit a *th* profile for both fields, with the same width but a different amplitude, possibly with a minus sign (antishock). We also performed a numerical study of the dynamics at large Prandtl. At times of order unity, some stationary configurations seem to be attractive; for example an initial condition with a negative velocity gradient tends to a configuration displaying a v–shock and a b–shock or b–antishock. We studied quantitatively this evolution by fitting locally the fronts by the exact stationary profiles, hence obtaining a precise description of the temporal evolution of the front width. A good agreement was obtained with an independent calculation of this width, based on its relation with the logarithmic decrement of the exponential fall–off of the energy spectra at very small scales. At much larger times, some of the stationary configurations appear to be only metastable. In particular the solution found by Passot evolves towards a configuration with a b–shock and a v–antishock. This may be interpreted in terms of rarefaction waves. One of our conclusions is that when fronts are present, they are locally well described by our stationary solutions.

FINE STRUCTURE OF COLLISIONLESS SHOCKS: THEORY AND OBSERVATIONS

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Well-accepted theoretical model of a quasi-perpendicular collisionless shock assumes that the shock front is one-dimensional and time-independent. With these assumptions the three-part structure of the high Mach number supercritical shock (foot, ramp, and overshoot) is qualitatively explained as produced due to the interaction of ions with the quasistationary electric and magnetic fields in the shock front. However, quantitative description is still lacking. The foot length is determined only by an order of magnitude, and it is unknown what determines the ramp width. On the other hand, observations show that there is no typical high Mach number shock profile, and the shock fine structure is rich. varying from almost stationary to clearly nonstationary (oscillating. for example). The shock front appears to be substantially structured, with the smallest quasi-stationary scales of the order of $0.1(c/\omega_{pi})$. We review the model of the one-dimensional stationary shock and observational evidence, together with the implications for further theory development.

ROLE OF CORONAL CONDITIONS IN THE DEVELOPMENT OF STREAMS, INSTABILITIES AND TURBULENCE IN THE SOLAR WIND

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In view of understanding the relation between coronal conditions and turbulence in the solar wind, we consider the problem of generating a stellar wind, using axisymmetric MHD simulations in an open domain containing the acceleration region. The magnetic field is the sum of an given external field and an induced field generated by the flow, the latter being rapidly dominant as distance increases. Various intensities and topologies of the external field are considered.
In the non-magnetic case, the existence of streams requires thermal inhomogeneities in the corona. Streams are then unstable if the thermal fluctuations are large enough, and the turbulent regions are the wakes of the (slow) cold streams embedded in between (hot) fast streams. The radial distance for turbulence onset and turbulent dissipation depend critically on coronal turbulent properties. A moderate magnetic field will act as a filter, restricting the existence of turbulent wakes to regions above closed magnetic field lines, above coronal streamers. The case of strong magnetic fields (i.e., low beta), is currently under investigation.

Analysis of the Seasonal Transport of Ozone and Water Vapor into the Lower Stratosphere

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The composition of the lowermost stratosphere is influenced by both the transport of well aged stratospheric air into the lowermost stratosphere, and the incorporation of fresher air more recently transported through the tropical and subtropical tropopause. Using model analysis, satellite data and chemistry codes the relative importance of these two processes are diagnosed as a function of the time of year in both hemispheres.

Arc-Polarized Discontinuities in the Solar Wind: Multispacecraft Studies

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We further examine the properties of rotational discontinuities in interplanetary space. We discuss the polarizations of the discontinuities relative to the ambient magnetic field and the solar wind velocity. The relationship of all RDs (regardless of polarization) with regard to Alfvén waves will be discussed. We will show that the Alfvén waves are phase-steepened with the RDs representing the phase-steepened front. We present a model explaining these waves as spherical waves with arc polarization.

We attempt to determine the direction of propagation of the waves using a spacecraft technique. We will compare the true RD direction of propagation to that of the minimum variance and intermediate variance directions.

ON THE SPECTRUM OF MAGNETIC FIELD FLUCTUATIONS IN THE SOLAR PHOTOSPHERE

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It is known that the fractal structure of the IMF depends on the structure of the magnetic field in the photosphere and the MHD turbulence in the solar wind. In this report we consider the process of generation of small-scale mag- netic fluctuations (<1000 km) by turbulent mo- tions of partially ionized gas in the photo- sphere. Using the model of weakly conducting fluid and assuming quasineutrality and isothermality, the relation between the magnetic field fluctuations and a random velocity field is derived from Ampere's law. Taking into account the Kolmogorov picture of the turbulence in the photosphere, an expression for the wave-number spectrum of the magnetic fluctuations is ob- tained. This spectrum is described by a power law dependence and discussed in the report.

ON THE INTERACTION BETWEEN HELIOSPHERIC MAGNETIC FIELDS AND LOCAL INTERSTELLAR MEDIUM IN THE HALE CYCLE OF SOLAR ACTIVITY

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It is known that during the moving of solar system in the apex direction relative to the local interstellar medium the latter exerts an action on the heliospheric structure making it nonspherical like a structure of the Earth's magnitosphere. It has been shown that if the rotation of the Sun is taken into consideration then its rotational velocities reveal a seasonal longitudinal nonuniformity with an annual periodicity. This effect manifests itself in studying both of rotation of the global large-scale magnetic structures (mean solar magnetic field) and rotation of the magnetic fields of active regions (flux solar radiation at $\lambda = 10.7cm$). For these structures of different scales the seasonal longitudinal nonuniformities of the rotation (acceleration or slowdown of the rotation relative to its average annual value) are opposite-in-phase so they can not be explained by the peculiarities of the Earth's orbital motion. There appears to be nonlinear counteraction effect within the system of the interrelated magnetic fields. The dynamics of these nonuniformities has been studied during the 22-year Hale cycle of solar activity using the data sets from 1976 to 1997. Some peculiarities of the dynamics of these effects have been discussed.

A COUPLED ICE SHEET-VISCOELASTIC EARTH MODEL AS A TOOL TO ASSESS THE PRESENT-DAY IMBALANCE OF THE GREENLAND ICE SHEET

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The present-day imbalance of large ice sheets is of great concern because of their potential contribution to global sea-level change. Unfortunately, the inference of this imbalance from either mass-balance measurements or from radar altimetry data is not very satisfactory yet (poor data coverage, controversy in satellite data..). An alternative method to derive this imbalance is to model the past behaviour of the ice sheet and to analyse the present evolution. Additionnaly, the gravity perturbation (from both ice and deep Earth spatial redistributions) can be used as a proxy so that coupling the ice sheet with a viscoelastic Earth model offers a new possibility of constraining the modern imbalance. This presentation aims at specifying how such a full ice sheet-Earth coupled model can help in extracting the elastic component from the total elastic-viscous gravity anomaly (which is actually measured) and also allows to correct for the height dependency in gravity values (free air gravity) by providing the crustal displacements. The patterns for the different gravity anomaly components as well as the present ice sheet imbalance given by the model for Greenland will be presented. These first results set the basis for a discussion on the possibilities of using field data to constrain the present-day imbalance of ice sheets.

WAVELET ANALYSIS OF GEOMAGNETIC TIME SERIES

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Within the framework of the project "Global Field Line Eigenmode Study" geomagnetic Pc3 and Pc4 types of pulsations are investigated. These phenomena are generated either by the solar wind or by the resonances of the lines of geomagnetic field. Baransky et al. published a method, called gradient method. to distinguish between the two possible driving forces of a given pulsation. This method uses the dynamic cross Fourier analysis of magnetic D or H component time series recorded at two stations located on the same geomagnetic meridian about 100-200 km apart. The fine spectral structure of the pulsations, i.e. their exact commencements and ends or their real frequencies. however. can not be appropriately determined from the spectrograms. The aim of this paper is to provide a tool to improve the resolution in the time-frequency domain with the use of simple and cross wavelet spectrum analysis. The authors expect that this type of analysis gives a better insight to the origin and dynamics of the resonances of both types.

ON THE UNIVERSAL IMPORTANCE OF SMALL SCALE ELECTROSTATIC STRUCTURES IN ACCELERATION/HEATING PROCESSES

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It was recently discovered by the Wind spacecraft that small scale coherent, electrostatic structures exist in the solar wind. They present important similarities with the structures already observed in the magnetosheath, magnetotail (observations by Geotail and Galileo) and in the auroral zones (observations by Viking and Freja). In a systematic way, this type of microscopic turbulence seems to be related to a dissipation of energy in the plasma and could thus be a very general ingredient of the acceleration/heating processes. The characteristics of these structures, their relationships to particular physical conditions and range of parameters will be discussed on the basis of the available observationsP and their potential importance in the acceleration/heating mechanisms will be analysed.

SYNERGETIC PROCESSES ON THE SUN AND THEIR RELATIONSHIP WITH SOME OBSERVATION DATA

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Corresponding to the basic conceptions of synergetics, in this paper is considered the possibility of realization of self-organizing processes on the Sun, which are expressed in the appearence of non steady-state periodic component in the solar energy transfer. The latter can be a natural cause for the observed characteristic pulsations of the Sun (T=160 min). They have no yet any satisfactory explanation. Up to now is accepted that the two thermonuclear cycles in the Sun: proton-proton (p-p) and carbon (CNO), are steady-state and have constant rate. It is supposed in the present paper that in reality exists a basic steady-state component of energy transfer. It follows the p-p cycle and is mixed with a non steady state component, which is connected with a non uniform (pulsations) regime of realization of the CNO-cycle. The latter has autocatalitic character and a strong temperature dependence of the different thermonuclear reactions. The nuclear system is described with the equations of Lotka-Volterra, which are solved for different temperature models. For the periods of oscillations $T=10^3$ - 10^4 s are obtained.

TESTING FOR FRACTAL STRUCTURE IN THE LOW-SPEED SOLAR WIND IN THE INNER HELIOSPHERE

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A time series of velocity fluctuations of the low-speed stream of the solar wind measured by the Helios spacecraft in the inner heliosphere is analysed. We invoke a modern method of singular system analysis to give a faithful representation of a fractal structure in the solar wind. In this way, the data are represented in terms of a complete set of orthogonal functions, obtained from a numerical analysis of the data, and not imposed from outside, as is in Fourier analysis or wavelets representations. It has been shown that singular system analysis is the powerful method of the reduction of the inherent experimental noise in the experimental data. This results in better characteristics of the structures and proves that this method is more adequate than a standard moving average smoothing. Furthermore, the obtained characteristics of the fractal structure are significantly different from that of the surrogate data. Thus the results of these tests suggest that the inner heliosphere is *nonlinear* deterministic system, at least in the inertial manifold of the phase space of this, as a whole, complex high-dimensional system.

OSCILLATORY DISINTEGRATION OF NONEVOLUTIONARY SHOCK WAVES

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We suggest a new scenario of nonlinear evolution of nonevolutionary MHD discontinuities. For such a discontinuity the problem of time evolution of its small perturbations does not have a unique solution. Therefore, it cannot exist as a stationary configuration and must disintegrate or transform to a more general nonsteady flow. Evolutionary are fast and slow shocks, while trans-Alfvénic shocks (TASWs) are not. This conclusion is valid for the shocks with both planar and nonplanar structure. The key feature of TASWs is that their disintegration configurations necessarily include an Alfvén discontinuity (AD) that is also nonevolutionary in the presence of arbitrarily small but nonzero dissipation. We show that the contradiction inherent in the nonevolutionary shock is removed if its evolution has the form of oscillatory disintegration, i.e., reversible transformation to the AD. We also apply the principle of evolutionarity to dissipative discontinuities in the profile of inviscid supercritical shocks. Using this approach, we obtain the conditions under which such shocks cannot exist as a stationary flow. In analogy with the shock as a whole, the nonevolutionarity of the internal discontinuity results in oscillatory reformation of the shock structure. We argue that the nonevolutionarity of TASWs is the reason why they are observed in the heliosphere much more rarely than fast shocks.

STRUCTURE FUNCTIONS AND SCALINGS ANALYSIS OF SOLAR WIND FLUCTUATIONS

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The solar wind is a turbulent magnetofluid. Intense fluctuations occur on a wide range of scales extending over several orders of magnitude. Clear evidence has been found in the data for intermittency and non-Gaussian statistics. To analyse these features the scaling properties of the fluctuations and their structure functions have been investigated in detail. Spacecraft observations show that the structure functions of the solar wind velocity and magnetic field, and of the proton density and temperature have scaling properties consistent with an intermittent behaviour. This is most obvious in the probability distributions, which reveal strong deviations from a Gaussian and indicate small-scale coherent dynamics. The turbulent kinetic energy flux shows multifractal scaling, which can be expressed and quantified in terms of its multifractal spectrum. Various theoretical concepts and models have been developed to explain the solar wind observations by invoking a fractal and scale-dependent energy cascade. A tutorial presentation of some of the models is given, and detailed comparisons of the data with the theories are presented.

MULTISCALE STRUCTURE OF THE INTERPLANETARY MAGNETIC FIELD: FRACTON EXCITATIONS AND THE POWER-LAW SPECTRA

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We study the statistics of the magnetosonic waves on the clusters of the IMF whose geometry is approximated by a fractal. Our prime interest concentrates on the role of these waves in formation of the power spectra of the IMF fluctuations in the corresponding frequency ranges. We argue that the magnetosonic waves on the fractal clusters of the IMF could be considered as a specific type of quasiacoustic excitations termed fractons (*Alexander and Orbach*, 1982) having an "unconventional" dispersion law depending on the topological properties of the fractal cluster. In this context, we propose a formalism which involves an investigation of the connectivity of the fractal sets. We propose an unconventional type of wave equation with the *fractional* time derivative, which generalizes the standard wave equation for the fractal geometries. We prove that the order of the time differentiation in this equation depends explicitly on the so-called index of connectivity of the fractal cluster. We found an analytical solution to the generalized wave equation on fractals, enabling one to calculate directly the power spectra of the IMF turbulence. Our results show a good agreement with the direct spacecraft measurements of the IMF turbulence in a wide range of frequences and heliocentric distances.

SINGULAR SYSTEM ANALYSIS OF THE SOLAR WIND

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The solar wind data, especially in the low-speed stream with irregular fluctuations of velocities, is a good candidate to apply the methods of nonlinear analysis. In the embedding space, constructed due to the Takens theorem, the singular analysis allows us to recognize the directions that are most frequently visited by the trajectory and by reducing the noise to estimate the dimension of the reconstructed space. The embedding space is represented by a complete set of orthogonal functions and is obtained from a numerical analysis of the data. The number of directions necessary for the complete reproduction of the nonlinear dynamic of the system should be large enough; otherwise the dimension of the subspace to which all the trajectories asymptotically approach could be underestimated. The obtained results were subjected to statistical tests for determinism and the results were significantly different than those obtained from the original data. Thus we can expect that the inner heliosphere is a nonlinear possibly chaotic system, at least in a submanifold of the phase space.

EXACT SCALING LAWS FOR TURBULENT MHD FLOWS

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Turbulent flows produce strong, sparse, localized structures which may give rise to anomalous exponents for the self–similar scaling of two–point structure functions of the physical fields. Such intermittency is constrained by exact laws stemming from the conservation properties of the dynamical equations, and is documented for the Solar Wind by several observations. In the case of laboratory experiments on neutral fluids, a better fit to the data obtains when, using Extended Self–Similarity (or ESS), one takes as the dependent variable (as contrasted with direct scaling with the distance r between the two points) the third–order correlators that are proportional to r. Such correlators can be viewed as "dynamical length scales" ℓ_{NS} that directly arise from the Navier–Stokes equations in the wake of the analyses of von Kármán and Howarth, of Kolmogorov as well as that of Yaglom.
The equivalent laws have been obtained in MHD for any amount of velocity–magnetic field correlation and for an homogeneous, isotropic and incompressible fluid. They lead to new dynamical lengths ℓ_{MHD}, and will be derived here explicitly in a simplified case. We thus suggest an ESS hypothesis for MHD that makes use of two sets of third–order *cross*–correlators written in terms of correlation or structure functions and involving *both* the velocity and the magnetic field. These *new* dynamical lengths are more appropriate candidates than ℓ_{NS} in the reduction of Solar Wind data, since they appear as fundamental correlators stemming from the non–linear dynamics of conducting flows.

A NUMERICAL STUDY OF THE CORRELATION BETWEEN DENSITY AND TEMPERATURE FLUCTUATIONS OBSERVED IN SOLAR WIND

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We compare the results of our numerical simulations with the analysis of the correlations between density and temperature fluctuations obtained from Helios 2 and Isee data. In our model, a spectrum of Alfven waves propagates across a spatially inhomogeneous magnetic field embedded in a plasma with a non uniform entropy distribution, that should modelize a magnetic sector boundary in the Solar Wind. We found that the interaction between the non compressive (Alfven) waves and the inhomogeneous structure produces compressive waves of two types: fast and slow magnetosonic waves, with a positive correlation between density and temperature, and static entropy waves. We found that, by going toward the smaller scales, the density-temperature correlation becomes more positive in the zone where the magnetic field is homogeneous, while it is negative in the inhomogeneous zone. That seems to be an indication of the fact that the static entropy waves are concentrated only in proximity of the inhomogeneity, where they are produced, whilst the magnetosonic waves propagate away, by filling the homogeneous zone as well. Analogous trend is got from the analysis of the data.

TERMINATION SHOCK EXCURSIONS: POSSIBILITIES FOR VOYAGER ENCOUNTER

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Fluctuations in the solar wind upstream of the termination shock as well as in the LIC plasma will cause inward and outward motions of the shock. In the paper we discuss various scenarios for the interaction between solar wind and interstellar matter including an influence of the local interstellar magnetic field on the heliospheric boundary configuration and a presence of interstellar neutral hydrogen.

ENTROPY OF THE SOLAR WIND FLOW IN THE INNER HELIOSPHERE

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We analyse a time series of velocity fluctuations of the low-speed stream of the solar wind measured by the Helios spacecraft in the inner heliosphere. We estimate the *Kolmogorov* entropy directly from the signal and show that the entropy is finite and positive, which is an indication for a chaotic behaviour of this complex system. These results supported our previous suggestion that trajectories describing the system in the inertial manifold of phase space can asymptotically approach the attractor of a low-dimension. Furthermore, the obtained characteristics of the attractor are significantly different from that of the surrogate data. Thus the results of these tests suggest that the inner heliosphere is *nonlinear* deterministic and possibly chaotic system, at least in the inertial manifold of the phase space.

SMALL ELECTROSTATIC POTENTIAL DROPS IN THE SOLAR WIND

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The TDS experiment on Wind detects electrostatic waveforms in the solar wind with a high temporal resolution. Weak double layers, lasting about 1 millisecond, are observed in the solar wind, except in the overdense heliospheric plasma sheet. In these weak double layers, the electrostatic potential generally drops antisunward: it varies in the same sense as the interplanetary potential which accelerates the solar wind protons. We discuss the occurrence and the amplitude of these small (3 to 20 mV) potential drops in relation with the direction of the magnetic field, the gradient of the electron thermal energy and the variations of the electron heat flux.

ION INJECTION, ACCELERATION, AND WAVE GENERATION AT THE QUASI-PARALLEL BOW SHOCK

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The processes of particle injection and acceleration and of upstream wave generation at quasi-parallel collisionless shocks are intimately connected and highly non-linear processes. The upstream waves are convected downstream by the plasma flow and are ultimately responsible for the shock dissipation. We have investigated the coupled process of particle injection/acceleration, wave generation, and downstream dissipation at quasi-parallel shocks by hybrid simulations, which treat the ions as macroparticles and the electrons as a massless fluid. Solar wind alpha particles are included self-consistently in order to make predictions as to the dependence of the injection rate on species and differences in upstream diffuse alpha particle spectra versus proton spectra. We will show that a large fraction of both protons and alpha particles are already accelerated at the shock before they leave the shock for the first time in the upstream direction. These ions are trapped near the shock ramp and are accelerated by the upstream wave electric field. We compare the simulations with a recent simplified model by Malkov (1997) for the ion injection at quasi-parallel shocks.

PROBABILITY DISTRIBUTION FUNCTIONS OF TURBULENT FLUCTUATIONS IN THE SOLAR WIND

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The probability distribution functions (PDF) of the velocity and magnetic field gradients in the solar wind have been analyzed using the Helios II spacecraft data collected in the inner heliosphere. We consider two different data sets, one including the slow-wind periods and the other one including the fast-wind periods. The PDFs have been fitted with a theoretical function representing a convolution between gaussian PDFs with variance distributed according to a log-normal function. The resulting PDF depends on a single parameter λ, which characterizes the intermittency of the signal, and we studied the scaling behavior of λ vs. the time-scale τ. We found that $\lambda \sim \tau^{-\beta}$, but two distinct values for β are present, at least in the slow-wind. No differences appear between velocity and magnetic field fluctuations.

ON THE NATURE OF INTERMITTENCY IN THE SOLAR WIND MHD TURBULENCE

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Thirteen months of velocity and magnetic field data from ISEE space experiment have been used to calculate spectra and structure functions using Haar wavelets thecnique.
Conditioned structure function definition allows

1. for the elimination of intermittency effects in spectra and thus for a clear identification of which kind of phenomenology of nonlinear cascade between Kolmogorov and Kraichnan is taking place in Solar Wind turbulence;
2. for the identification of the most intermittent structures, which turn out to be either shock waves or one dimensional current sheets,in contrast with ordinary fluid intermittency, where the most intermittent structures are two dimensional vortices.

SELF-SIMILARITY CONCEPTS FOR GEOMAGNETIC PULSATIONS

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Recent analysis has shown that low frequency geomagnetic fluctuations exhibit the same kind of scaling symmetry as MHD turbulent flows in the solar wind. In this paper we analyse geomagnetic fluctuations on the time scale of geomagnetic pulsations. We use the data from two station pairs in Central Europe and in Colorado, USA. First, we identify pulsations which characteristics are controlled by the solar wind and separate the frequences of others which are controlled by resonances (eigenmodes) of individual field lines. To this end we use gradient methods and continuously compute cross power spectral density and cross phase dynamic spectra. After the separation of quasi-periodic (field line resonance) and broad-band components we apply the methodology of extended self-similarity to study scalings. The aim of this study is to understand better the position of the geomagnetic pulsations in a complex energy cascade with the driving energy source arising from the non-local interaction between the solar wind and the magnetosphere.

PROPERTIES OF THE SOLAR WIND TURBULENCE AS REVEALED BY THE WAVELET TRANSFORM

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Solar wind turbulence is highly nonhomogenous, exhibiting well localized jumps, spikes and discontinuities. These coherent structures are apparently caused by nonlinear processes and play an important role in the dynamics of turbulent plasma. The usefulness of the wavelet transform in studying turbulence stems from the fact that it can be performed locally, preserving the information about local features of the turbulence. We show that the high-frequency ($\geq$0.01 mHz) local wavelet spectra of the Elsässer variables of the low-speed solar wind at 0.3 AU are highly variable along the Helios 1 orbit. Application of the wavelet-based nonlinear filtering allowed us to separate coherent structures from the noise-like, Gaussian background. Spectral indices of the Elsässer variable Z+ are approximately -2 and -1 for the coherent and noise-like components, respectively. Flatness of the wavelet coefficients show that the outward propagating perturbations are non-Gaussian at scales less than 30 minutes, while the inward perturbations become non-Gaussian at time scales less than 1 hour, confirming the earlier results.

ST7

ST7 Nonlinear processes in the ionosphere and magnetosphere (co-sponsored by NP)

Convener: Rycroft, M.J.
Co-Convener: Fontaine, D.

FINITE ELECTRON MASS IN MAGNITOHYDRODYNAMIC THEORY. STRONGLY NONLINEAR PERIODIC WAVES AND SOLITON.

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Starting from the multi fluid hydrodynamic approximation we have got the generalazation of Ohm's Law in usual magnitohydrodynamic (MGD) theory. MGD approximationIt is well known to be valid only for low frequency perturbation, i.e. that frequency should be much less ion hyrofrequency ω_{Bi}. Our equations take into account both Holl effect and the finite value of electron mass. It is allow us to describe all low frequency spectra ($\omega \leq \omega_{Be}$) in 2-component low density ($\omega_{Be} \ll \omega_{pe}$) plasma. We have got also an exact solution of generalized MGD equations. There are the waves (periodic and soliton-like) traveling perpendicular to external magnetic field. We have calculated maximum amplitude of magnetic field for that wave. The nature of the wave dispersion is essential electro-magnetic, because plasma is localy quazineutral for any wave amplitude.

FIRST EVIDENCE OF SPECTRAL RESONANCE STRUCTURE (SRS) OF ULF BACKGROUND ELECTROMAGNETIC NOISES AT THE POLAR REGION.

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A high-sensitive, two component induction magnetometer has been used for measurements of natural electromagnetic noise in the frequency range 0.1 - 10 Hz. Observations were carried out at the receiving site Kilpisjarvi (L = 6) during the 1-st Finnish EISCAT-Heating Campaign in November, 1993. We have examined the average magnetic spectra for four magnetic polarizations (linear, N-S and E-W, and circular, R and L) with spectral resolution of 0.1 Hz and time resolution of 15 min. During at least four out of twelve nights covered by measurements, clear evidence of Spectral Resonance Structure (SRS) was obtained in the magnetic spectra. The SRS is appeared in a deep sinuousform modulation of noise spectral amplitude along the frequency axis with 3-4 spectral maxima and distance between ones, varied over period of measurements from 0.5 to 1.5 Hz. The temporal variations of SRS pattern differed from those of-midlatitude ones, as observed near N.Novgorod, Russia but were in a good accordance with EISCAT measurements of electron density in the F-layer of ionosphere.

ELECTROMAGNETIC REMOTE SOUNDING OF RESONANCE PROPERTIES OF POLAR IONOSPHERE IN THE ULF FREQUENCY RANGE 0.1 - 5 HZ WITH USING OF HF POWERFULL HEATING FACILITY.

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Measurements of ULF (0.1-5 Hz) artificial signals excited in lower ionosphere by amplitude modulated HF (4-6 MHz) radiation from "Tromsø" heating Facility were performed by joint Russian-Finland scientific team during the 1-st Finnish EISCAT-Heating Campaign in November, 15-19, 1993. At the receiving site "Kilpisjarvi"(100 km from Facility), four magnetic field polarizations were available in measurements - two linear and two circular ones. Clear sinuousform amplitude-frequency responce of signals was detected. The distance between two neiboring amplitude maxima or minima along frequency axis varied from 0.5 to 1.5 Hz with dependence on daytime conditions of experimental cycles. This resonance frequency pattern was more visible for artificial signals (derived by coherent integration) then the exhibition of Spectral Resonance Structure of background magnetic noises, derived from averaged noise spectra in the same time and which is discussed in accompanied communication.

FIRST TEST MEASUREMENTS OF ARTIFICIAL ULF SIGNALS AT THE LONG DISTANCE 1500 KM

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During September 18-19, 1993, RIPR, St.-Petersburg and NIRFI, N.Novgorod, Russia performed the first measurements of artificial ULF signals in the frequency range 1-5 Hz at the distance of 1500 km between transmitter and receiver. The ULF Facility, located at the Kola peninsula, near Murmansk, Russia was consisted of 55-km powerline with radiation current of 150 A and was grounded at both ends. The operating frequencies were 1.3, 2.6 and 5.2 Hz (20 min "on", 10 min "off") during each of three 2-hour cycles a day, evening and early morning conditions. The receiving site was located near N.Novgorod and provided the measurements of two H_{N-S} (H) and H_{E-W} (D) magnetic components. The observed magnetic field strengths and magnetic vector polarizations were found to be in line with the simple waveguide-cavity theory predictions for daytime conditions and to be in a dramatic discrepancy for nighttime ones. The measured distinctions can be explained by a significant influence of an additional portion of the magnetic signal ducted into MHD-ionospheric waveguide and by ionospheric resonance properties (Ionospheric Alfven Resonator) above transmitter and receiver.

PARAMETRIC DECAY OF ELECTROMAGNETIC PUMP WAVE IN TWO-DIMENSIONAL INHOMOGENEOUS PLASMA

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Due to the action of strong HF electromagnetic waves artificial plasma irregularities appear in the ionosphere which have an influence on various nonlinear effects, e.g. stimulated electromagnetic emission (SEE). Different processes including decay instabilities are responsible for the peculiarities of the broadband spectrum of the SEE. Up to now decay instabilities in relation with SEE were discussed neglecting longitudinal inhomogeneity of the medium and wave propagation along the magnetic field line. These two factors may reduce considerably the wave interaction. We consider the decay instability of the EM pump wave into upper hybrid (UH) and lower hybrid (LH) waves as a first step in the creation of the downshifted maximum (DM) in the SEE. In distinction from previous papers the case when UH waves are trapped in weak plasma enchancements along the magnetic field line is investigated. It is shown that transversal inhomogeneity of the medium is also very important and should be taken into account. The linear stage of instability is analysed and the frequency range of the excited UH waves is found. It is shown that such spectrum is similiar to the spectrum of DM in SEE.

EXPERIMENTAL INVESTIGATIONS OF THE IONOSPHERIC ALFVEN RESONATOR FROM ELECTROMAGNETIC NOIS BACKGROUND OVER THE SOLAR CYCLE OF 1985-1995

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Based on long-term observation of the resonance structure in the magnetic field spectrum (RSS), recorded in the frequency range of 0.1-10 Hz over one complete solar cycle (11 years), it was found, that the resonance conditions for the Alfven waves in the ionosphere (ionospheric Alfven resonator) are determined by the level of the solar activity. RSS are regulary observed in years of minimum solar activity, and are practically absent in years of maximum solar activity. These experiments were performed during 1985-1995. It was shown thereby, that the consideration of the ionospheric Alfven resonator will allow to explain the dependence of the RSS on the solar activity.

ON THE PEDERSEN CURRENT CARRIED BY ELECTRONS

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According to text books the Pedersen current is carried by ions and has a maximum flow around an altitude of 125 km. When the perpendicular electric field in the ionosphere gets sufficiently large, then the Hall current at heights around 108 km becomes unstable. The excited plasma waves reflect VHF radio waves leading to the so-called radio aurora. Farley (1963) and Buneman (1963) first treated the linear theory of this current instability. From observations using incoherent scatter radars it is also known that during such strong electric field events the electrons in the E region get heated and a substantially enhanced temperature is maintained against the relatively intense cooling processes in the atmosphere. In this talk we show, that then, as the conservation of energy implies, the wave-electron interaction in the quasi-linear stage must lead to a Pedersen current carried by electrons. Both, the heating and deflection of the electron drift vector from the ExB direction limit a further growth of the waves. Using EISCAT observations and models for the cooling processes, we estimate the electron Pedersen current to amount to about 20 percent of the ion Pedersen current once the instability threshold is exceeded. The ionospheric instability mechanism considered by us might play a triggering role for the excitation of other instabilities and reconfiguration in the ionosphere-magnetosphere coupling.

DYNAMICAL RAY FOCUSING IN INHOMOGENEOUS PLASMA

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Ray dynamics is investigated by Hamiltonian mechanics method. For certain values of the parameters of smooth and periodic inhomogeneities, it is possible a dynamical ray focusing.

It has been determined the conditions on which rays oscillate around the position of the synchronous ray, and there takes place a dynamical ray focusing.

The focusing caused by a periodic inhomogeneity is similar to the secondary resonance in the resonance theory of perturbation in Hamiltonian systems. On certain conditions, there may take place an overlap of the regions corresponding to nonlinear resonances in the phase space, and this results in spatial fluctuations of rays becoming chaotic.

INFLUENCE OF PLASMA DENSITY FLUCTUATIONS ON PLASMA-BEAM INTERACTION

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It is investigated the instability of the beam that moves in plasma with the density which stochastically varies in space or time.

The dynamics of any order of moments is studied when the plasma density changes in space or time. It is shown that every sequential moment grows faster than the previous one. The increment of the second moment exceeds the increment of the regular part of the signal more than two times. The result of this dependence of increment is punctuate character of instability growth and the appearance of some critical length of interaction area where the amplification of the regular signal is possible yet. The maximum time what need for signal destroying by fluctuations is calculated.

CHORUS EMISSIONS PRODUCED BY A BACKWARD WAVE OSCILLATOR IN THE MAGNETOSPHERIC CYCLOTRON MASER

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The influence of the inhomogeneous geomagnetic field on the backward wave oscillator generation regime in the magnetospheric cyclotron maser is considered. This regime is due to the absolute instability of a quasimonochromatic whistler wave in the near-equatorial region of the Earth's magnetosphere caused by energetic electrons with a step-like deformation of the distribution function in parallel velocity. Such a deformation is formed due to the quasi-linear interactions of energetic electrons with noise-like emissions having an upper frequency cutoff. In this paper, it is proven that the absolute instability leading to the backward wave oscillator generation regime can be achieved for magnetospheric conditions. For this, the linearized self-consistent equations for the wave amplitude and energetic electron resonant current in a parabolic external magnetic field are solved. The spatial profile of a whistler mode wave formed due to cyclotron resonant interactions is determined; threshold parameters for the absolute instability are obtained. The implications for chorus generation in the magnetosphere are discussed.

RECENT DEVELOPMENTS IN THE CHARACTERIZATION OF NONLINEAR WAVE PHENOMENA IN SPACE PLASMAS

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Progress in understanding nonlinear phenomena in space plasmas is intimately related to our capacity of characterizing such phenomena by means of physically relevant concepts. During the last decade, many developments in that field have shown that it is still open to considerable progress. Some of these novel concepts are reviewed here.

The emphasis is put on a series of concepts that are intimately related : topological properties (scaling laws, self-similarity), complexity (hierarchical structures) and self-organisation (coherent structures). Through a review of recent results obtained in space plasmas, the inference of these properties from experimental data and their relevance (or irrelevance) for the study wave phenomena will be discussed.

A DYNAMICAL STUDY OF INDUCED SCATTERING

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We investigate dynamical properties of a simple model of electrostatic wave-wave interaction in the induced scattering limit (case of an isothermal plasma), without making use of the random phase approximation (Zakharov, V.E., Musher, S.L. and Rubenchik, A.M., Sov. Phys. JETP **42**(1), 80-86 (1975)).

PULSATING AURORAS AND THEIR CONNECTION WITH VLF EMISSIONS OBSERVED IN NORTHERN FINLAND

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Pulsating aurora is a substorm recovery phase phenomenon and is mainly seen on the morning side of the auroral oval. The pulsating precipitation of the auroral electrons is a consequence of wave-particle interactions in the magnetosphere close to the equatorial plane. These wave-particle interactions between whistler-mode VLF waves and magnetospheric electrons lead to a pitch angle diffusion of the electrons and this can lead to precipitation of the electrons into the ionosphere. This pulsating precipitation is then seen as auroral intensity pulsations. Models of pulsating aurora are based on the cyclotron instability of trapped particles.

Simultaneous auroral and VLF measurements have been made during EISCAT and VLF campaings in Northern Finland every winter since 1990. Auroral recordings are made using a low-light-level TV camera. VLF signals (200 Hz - 9.2 kHz) detected by two loop antennas are recorded on audio tracks of the same video tape as auroral measurements. TV recordings are analyzed by digitizing them and VLF recordings are analyzed by an analysis package developed at the Sodankylä Geophysical Observatory. The measurements presented here were made at Porojärvi (69.17°N, 21.47°E) in 1993, 1997 and at Kaikkoaivi (68.73°N, 22.11°E) in 1994. Here we present some results of the connection between pulsating auroral patches and VLF emissions.

ON PARTICLE ACCELERATION BY LOWER HYBRID TURBULENCE DURING IONOSPHERIC MODIFICATION EXPERIMENTS

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The acceleration of ions and electrons by lower hybrid turbulence is widely used for the interpretation of particle spectra in space and laboratory plasmas. On the other hand, excitation of the lower hybrid turbulence appears to be a necessary element of the generation mechanism of the outshifted plasma lines and stimulated electromagnetic emission, observed during the injection of intense HF radiowaves into the ionosphere. It is the aim of our paper to define the parameters of the accelerated electron and ion spectra characteristic of the ionospheric modification experiments in the polar ionosphere.

ON THE NONLINEAR TRIGGERING OF VLF EMISSIONS BY POWER LINE HARMONIC RADIATION

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The Jan 1993 VLF campaign by Sodankyla Geophysical Observatory at Porojärvi in Northern Finland has produced a remarkable data set of VLF emissions. The data is characterised by a high incidence of power line harmonics, and also by frequent echoing of events up to six times. The PLHR lines are identified as being due to the Finnish power system, since the dominant lines occur at f=50·(12n±1) Hz. There is clear evidence that these PLHR lines penetrate the magnetosphere and trigger VLF emissions in the equatorial zone. A wide variety of emission forms are noted, namely steep multiple risers, upward and downward hooks. In this paper we numerically simulate emissions triggered at 2950, 3650 and 4150 Hz. The code is a 1D EM code using the Vlasov Hybrid Simulation technique (VHS). It assumes parallel propagation and a hot anistropic electron distribution function giving linear growth rates ~60 dB/s. The code has a bandwidth ~50 Hz, and permits linear spatial variations of wavenumber. Making plausible choices for L shell and equatorial cold plasma density, successful simulations have been made of PLHR triggered risers, fallers and upward hooks. Simulated sweep rates ~1 kHz/s were in very good agreement with the data. The simulations also revealed key aspects of the phenomenon of triggered VLF emissions. When the equatorial linear growth rate exceeds a threshold 50 dB/s the plasma becomes nonlinearly absolutely unstable. At the end of the linear growth phase, a stable nonlinear structure termed a generation region (GR) is set up. Risers and fallers have different distinct GR structures, and hooks result when GR type changes. Interestingly the basic physics of VLF emissions is almost the same, wether one is at L=3, 4, 5, 6 or 10.

MODULATIONAL INTERACTION OF LOWER-HYBRID WAVES AND FORMATION OF COHERENT STRUCTURES IN THE MAGNETOSPHERE

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A universal nonlinear formalism is presented for the description of the dynamics of random and regular lower-hybrid fields. This formalism allows us to obtain the integral equations describing the modulational instability of spectra of lower-hybrid waves, find the rates and thresholds of the instability. It is shown that the appearance of the instability thresholds is possible only for the spectra which occupy the whole region in the wave vector space where the waves can exist. The instability is investigated in detail for the parameters of the waves and the magnetospheric plasma inherent in the conditions of the observations carried out by the satellite Freja. It is shown that the coherent field formation and, correspondingly, the formation of the state of strong turbulence in the magnetospheric plasma is connected with the development of the modulational processes. In particular, the magnitudes of the threshold density of the lower-hybrid fields, which characterize the process of excitation of regular fields in the Earth's magnetosphere and have been observed by the satellite Freja, are explained by considering the thresholds of the modulational instability.

MAGNETOSHEATH'S MODEL IN THE CGL APPROXIMATION

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Parameters of the solar wind plasma and magnetic field in the magnetosheath in dependence on the IMF orientation are calculated for an anisotropic plasma in the CGL-approximation. There is shown that for given parameters of the solar wind, the temperature anisotropy of the magnetosheath plasma results in a decrease of the magnetic field intensity and of the plasma density at the magnetopause, especially for a southward IMF. Influence of the pitch-angle diffusion of protons on the magnetosheath parameters is discussed.

DEMODULATION OF HF RADIO TRANSMITTER SIGNALS BY THE POLAR ELECTROJET

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The ionospheric demodulation of modulated signals from HF broadcasting transmitters by the polar electrojet is considered. The main effect is caused by the formation of an ionospheric travelling wave antenna. This antenna radiates demodulated ELF/VLF waves in two directions, one of which coincides with the line connecting the broadcasting transmitter with the ELF/VLF receiver, and the other is the mirror image of this line relative to the direction of the ionospheric current. In this paper, attention is paid to the demodulation effects from the curved and non-stationary electrojet. It is shown that the curvature and temporal variations of the polar electrojet can lead to focusing or defocusing of the demodulated ELF/VLF signal, causing fast variations of its amplitude and polarisation. Quantitative estimates of these effects are presented.

THE ROLE OF THE ELECTRON-TO-ION TEMPERATURE RATIO AND TRANSIENT ELECTRONS IN THE LINEAR STABILITY OF THE QUASI-NEUTRAL SHEET TEARING MODE

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The linear stability of the tearing mode in the magnetotail current sheet with nonzero normal component of the equilibrium magnetic field first obtained by Lembege and Pellat [1982] considered the electrons to be trapped in the current sheet. The sufficient stability criterion severely limits tearing instability, interpreted as due to electron compressibility. The electron population in the current sheet however consists of trapped as well as transient populations. The integral equation for the perturbed electron density including both trapped and transient populations is obtained within the drift kinetic approximation. It is shown that due to the transient population the electrostatic contribution to the flux tube integrated electron density does not vanish, but dominates at sufficiently small electron temperature. The formation of the plateau in the local density profile along the field line at sufficiently small T_e/T_i is demonstrated and a new sufficient criterion of stability is obtained. As compared to the original criterion of Lembege and Pellat [1982] the stability condition is reduced by a factor of $(3T_e/T_i)^2$. Thus marginal stability state may be reached for sufficiently cold electrons as noted earlier by Schindler [1974].

SPRITE EFFECTS ON THE IONOSPHERE

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Sprites and Elves are brief luminous flashes, occurring over mesoscale convective systems at altitudes of about 50 – 90 km and preceded by strong tropospheric discharges. Their mechanisms are believed to be the direct heating of free electrons up to a few eV and the breakdown of the atmosphere (at heights where the density is sufficiently low) due to the large electromagnetic and quasi-electrostatic fields, or/and the runaway breakdown initiated by cosmic rays. These strongly nonlinear processes are associated with a large transient current and convert a part of the LF – HF energy, as well as a part of the electrostatic energy of the tropospheric discharge, into the energy of the transient ULF – ELF radiation (*Sukhorukov et al.*, GRL **23**, 2911, 1996; *Sukhorukov and Stubbe*, GRL **24**, 829, 1997: GRL **24**, 1639, 1997). The energy conversion results in an unusually effective excitation of a number of the large-scale electromagnetic resonance phenomena in the Earth environment, such as the Schumann resonances and the transversal resonances of the Earth-ionosphere cavity, and the Alfven resonances in the upper ionosphere. A review of these and of a number of other Sprite-related nonlinear phenomena in the ionosphere, already discovered or predicted, will be given.

NONLINEAR INTERACTION OF WHISTLER WAVES WITH A MODULATED THIN ELECTRON BEAM

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The nonlinear theory of a thin modulated electron beam interaction with a monochromatic whistler wave is considered. The self-consistent set of differential equations describing the wave amplitude evolution and the beam particles motion has been solved by a computer code. We discuss here the results issued from the numerical solution of the differential system, and namely the physical features of the nonlinear beam-wave interaction (trapping, slowing down of the beam, wave damping, multiple bunching, beam focusing) as well as the influence of the physical parameters on the wave emission: beam energy and density, initial beam velocity distribution and beam current modulation. We have shown that the trapped particles are the source of the emission: they are decelerated in phase with the wave and remain in Cherenkov resonance with it owing to a nonlinear shift of the parallel wave number. No quasi-periodic exchange of energy between the wave and the particles has been observed.

LINEAR AND NONLINEAR PROPERTIES OF ALFVÉN WAVES IN PLASMAS CONTAINING HIGHLY CHARGED IMPURITIES OR DUST

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Processes in dusty plasmas are being studied intensively because of their importance for a number of applications, in particular in plasmas of the Earth's environment.
The dust affects plasma collective properties in many ways. The simplest effects are due to the charged dust grains carrying a proportion of the negative charge of the plasma. Even if this proportion is quite small and the dust dynamics is ignored, it can have a large effect on propagation of some waves (e.g., hydromagnetic Alfvén waves at frequencies below the ion-cyclotron frequency). We consider dispersion characteristics of low frequency electromagnetic waves propagating in a magnetized plasma with immobile dust grains and finite electron temperature. Modification of the Alfvén resonance absorption mechanism due to the presence of the dust is discussed. Nonlinear effects in propagation of Alfvén waves parallel to the external magnetic field are considered, and surface Alfvén waves are discussed. Also, formation of shocks in dusty plasmas is examined.

Self-affine fractal dynamics of the activities of the Sun and magnetosphere of the Earth

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At the analysis of dynamics of solar (international SunSpot Number - SSN and SOLAR RADIO FLUX 10.7 sm - SRF) and geomagnetic (Ap- and Dst-indexes) activities (everywhere - daily average meanings for the period with 1960 for 1996 years) within the framework of the concept of the stochastic fractals with the methods of the Hurst (H) and calculations of fractal dimension on a covering it is shown, that chaotic dynamics of all indexes (without periodic components of 22-year's cycle) - self-affine stochastic fractals: H(SSN)=0.74, H(SRF)=0.82, H(Ap)=0.63, H(Dst)=0.80. Are considered the fractal dimensions and statistics of distribution of characteristic time's intervals for all processes. Is shown the dynamics of dimensions in a cycle of solar activity. Fractal properties of SSN correlate with fractal properties Ap, and SRF correlates with Dst. Statistics of time's intervals various for all indexes. Is shown that the minimum by derivative from dynamics of yearly average meanings of SSN corresponds to a maximum of fractal dimension of geomagnetic activity and vice versa. Generation chaotic components on the Sun are not connected to generation periodic components of solar activity. Periodic component of activity of the Sun influences on chaotic dynamics of geomagnetic activity. Annual dynamics of fractal dimensions of SSN (SRF) in dynamics of geomagnetic activity is not observed. Annual dynamics of fractal dimension Ap correlates with dynamics of yearly average meanings Ap, but for SSN, SRF and Dst such correlation is not observed. Marked by Hurst the fact, that the nature chooses H ‡ 0.7 in global situations, finds the confirmation in indexes of the activity of the Earth and Sun.

COLLECTIVE CHARGING PROCESSES IN DUSTY PLASMAS

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Processes in dusty plasmas are being studied intensively because of their importance for a number of applications, in particular in plasmas of the Earth's environment.
The dust grain charge is mostly determined by plasma currents. We focus our attention here on this charging machanism, and consider its influence on plasma waves. The main difference of dust particles from heavy ions is that the dust charge is not fixed. Thus plasma collective perturbations lead to dust charge fluctuations which in turn affect the plasma waves. Physical processes with frequencies of order or less than the dust charging frequency are strongly affected by the dust charge fluctuations. The kinetic theory of a dusty plasma taking into account the dust charge perturbations is discussed.

ST8 The high-latitude ionosphere and magnetosphere: coupling and solar wind forcing

Convener: Woch, J.
Co-Convener: Villain, J.-P.

GEOPHYSICAL EFFECTS OBSERVED BY GROUND-BASED HF DISTANCE DIAGNOSTIC TOOLS DURING TROMSØ HEATING EXPERIMENT

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Results are presented from the Tromsø Heating experiment on 17 February 1996 in the E_s-layer of the auroral ionosphere during magnetospheric substorm in which HF distance diagnostic tools located in St.Petersburg, Russia, combined with multi-instrument observations at Tromsø, Norway, were employed. Observed geophysical phenomena initiated by the Tromsø HF heater action on the nightside auroral E_s region of the ionosphere are the following: (1) the appearance wave variations in Doppler frequency shifts correlated with magnetic pulsations in the D-component at Tromsø within Pc4 range (115 s) coinciding in time with the onset of the substorm expansion: (2) the evidence of local substorm current changes; (3) stimulated electron precipitation lasting for 40-60 s due to a cyclotron resonant interaction of natural precipitating electrons with heater-induced whistler waves in the magnetosphere during substorm expansion. Obtained results clearly show the evidence on the modification of the ionosphere-magnetosphere coupling during magnetospheric substorm produced by powerful HF radio waves in the auroral E_s region of the ionosphere.

SUPERDARN OBSERVATIONS OF SMALL-SCALL EXPANDING STRUCTURES

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The F-region plasma is usually totally magnetized and flows across the magnetic field with a velocity V = ExB/B2. This explains why we can expect a divergence free motion of the plasma in the plane perpendicular to the magnetic field. In this presentation, we present several cases where the plasma motion is locally highly divergent and forms a small-scale expanding structure. They have been always observed during periods of northward interplanetary magnetic field, near the polar cap boundary, in the nighside ionosphere, where the convection pattern is very irregular for Bz north. No global motion of the structures is observed, their lifetime is about 5-10 minutes and their characteristic scale size is about 150 km. In this presentation, we describe those event in terms of ions demagnetization in the F-region. By using a description of the data with the collective wave scattering theory, we also show that the turbulence regimes inside these structures can be described as a demagnetization event. We explain those events by an anomalous transport induced by turbulence, raising from a plasma-beam interaction. This process is then related to the global geophysical condition, when the interplanetary magnetic field is northward.

FORMATION AND EVOLUTION OF SAID IN THE COURSE OF A SUBSTORM

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We propose a physical mechanism that explains why subauroral ion drifts (SAID) are formed in the course of a substorm and how they evolve. An SAID is considered to be the ionospheric signature of a magnetospheric interface between the cold plasmatrough and hot injected plasma moving inward. The flow shear that exists across such an interface in the vicinity of the plasmapause is responsible for the generation of intense electric fields in the pre-midnight sector, where SAID are observed. Quantitative simulations confirm that this mechanism accounts for SAID width and peak drift velocity. The mechanism explains why SAID are never observed equatorward of the plasmapause. The inward traveling time of the injected plasma agrees with the delay between substorm onset and the apparition of SAID; the evolution of the ionospheric drift profile is consistent with observations as well.

HIGH-LATITUDE IONOSPHERE AND MAGNETOSPHERE DEPENDENT ON THE SOLAR WIND MAGNETIC FIELD

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Solar wind magnetic field orientation determines the global magnetospheric magnetic field structure and corresponding high-latitude quasi-static ionospheric convection in two hemispheres. Dependent on interplanetary magnetic field (IMF) orientaton, different types of reconnection exist: two-dimensional reconnection at merging line for southward IMF; three-dimensional reconnection at neutral points for northward IMF; simultaneous existence of both of these merging types for near-radial IMF. For the near-radial IMF, ionospheric convection pattern represents on principle new structure reflecting features of both two-dimensional and three-dimensional mergings existing simultaneously. Together with vortex pattern and reverse convection, only a part of an open field line region's boundary is equipotential. The other part includes ionospheric projection of merging line, which is intersected by open and closed field lines during their convection.

STRUCTURE OF AURORAL PRECIPITATION IN MAGNETOSPHERE MORNING SECTOR: RELATION WITH CONVECTION REVERSAL BOUNDARIES AND FIELD-ALIGNED CURRENTS

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Location of boundaries of various structural regions for near-midnight sector of magnetosphere was discussed in detail by *Newell et al [1996], Feldstein and Galperin* [1996]. This classification is based on physically substantiated boundaries of regions with different physical characteristics as far as structure of precipitating plasma fluxes and their energy spectra in the interval from dozen eV to dozen thousands eV are concerned. The precentation covers auroral plasma precipitation structure in magnetospheric morning sector based on similar data about simultaneous intersections of high latitude region by Viking and DMSP F7 satellite. The structures classification strongly relies on plasma fluxes spectrogramms, their pitch-angle characteristics and morphological peculiarities. Relationship among plasma structures and location of Region 1/Region 2 field-aligned currents, large-scale magnetospheric convection is discussed. *FAC* intensity and direction was determined on the basis of magnetic field variations measurements on board DMSP F7 and Viking, while convection direction was determined based on Viking observations of electric fields.

INNER MAGNETOSPHERE RESPONSE TO THE PASSAGE OF HELIOSPHERE CURRENT SHEET

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During a CME positive phase on Jan. 11, 1997, When Geotail was moving in the near-Earth duskside of LLBL (Low Latitute Boundary Layer), several energetic ions bursts were detected by HEP-LD instrument. Such ions bursts were closly related to the passage of the Filament or the Heliosphere Current Sheet (HCS) which embedded in this CME event. The magnetosphere was relatively quiet whereas the DST index get rather high positive values.
The present paper concentrates on composition observations obtained by the energetic ion spectrometer HEP-LD. The variation of composition during the passage of HCS/Filament was obvious. How a HCS/Filament interacts with the magnetosphere and its physical impliation will be discussed.

ANALYSES OF RELATIONSHIP POLAR ARC TO LARGE-SCALE ELECTRODYNAMICS

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Using Viking and DMSP satellite data calculations of the large scale high-latitude ionospheric convection associated with polar cap arcs are fulfilled. On Aug., 3 and Sept., 25, 1986 bright transpolar arcs were located in the northern polar cap. Background high-latitude field-aligned currents (FAC) for these periods were reconstructed from IZMEM model [1] on base of solar wind parameters. Field-aligned currents for polar arcs were reconstructed using the model [2]. Calculations show that: 1)increase of the conductivity connected with the polar arc changes large-scale convection insignificantly; and 2) FAC of polar arc may change this convection near arc area more essentially. Space distributions of the ionospheric convection and the magnetic field on the ground level associated with polar cap arcs are demonstrated.

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OBSERVED POLAR CAP IONOSPHERE DEPENDENCE ON IMF

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The agents that control the polar cap ionosphere morphology have probably all been identified and their effects explored through model studies. Many of the effects have been clearly substantiated by measurements, such as UT, seasonal, hemispherical, and solar cycle dependencies. Magnetospheric control has been less thoroughly explored. Dependencies on magnetic activity have been singled out - complex time-dependent changes are the most characteristic consequences of enhanced magnetic activity. The direction of the interplanetary magnetic field (IMF) could have a more clearly defined effect since the polar cap distribution of ionization is strongly dependent upon the convection pattern. Sorting through complete data sets from several ionospheric satellites, from near Fmax well into the topside ionosphere, a clear IMF effect on the ionosphere was not found in the measurements from all satellites. Nevertheless there are data sets that provide statistical evidence for ionosphere electron density differences between the dawn and dusk sides of the polar cap when the IMF component Bz was negative. The asymmetry in local time was opposite for the northern and southern polar cap, and was opposite for positive and negative By directions. No patterns could be clearly attributed to a By positive state. These observations are consistent with modeled expectations.

New method for reconstruction of the polar convection pattern

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A new method is suggested for restoration of instantaneous convection pattern in the Earth's polar ionosphere. The method uses the electric field vector measurements along the polar orbits as input data. Plasma convection in the polar cap ionosphere is described as a hydrodynamic incompressible flow. This description is valid in the region where the electric currents are field aligned (and hence, the Loretz body force vanishes). In addition, the problem becomes two-dimensional, and may be described by means of stream function. Then, a solution of hydrodynamic equation for stream function can be found in the polar cap regions surrounded by segments of satellite trajectories, if the electric field vector components, measured along the trajectories, are taken as boundary conditions. This solution corresponds rather well to the 'true' convection picture and may be considered as a restored 'effective' convection pattern. It is shown that the convection pattern may be restored with a reasonable accuracy by means this method, by using only the minimum number of satellite crossings of the polar cap.

CONJUGACY OF GEOMAGNETIC DISTURBANCES IN THE AURORAL OVAL POLEWARD AREA

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The latitudional distribution of the geomagnetic field components are analyzed using the records from the meridional chain of magnetometers in Scandinavia, Nord in Greenland, Mirny and Komsomolskay stations in Antarctica. A particular consideration is given to a poleward expansion of the westward auroral electrojet during the substorm expansion phase which occurs in a course of a development of the magnetic storm main or recovery phases. The latitudinal region where the westward electrojet is located in the Northen hemisphere is compared with the westward electrojet polar edge location in the Southen hemesphere. Various effects depending on the magnetic storm intensity and differences between latitudinal distributions are investigated and discussed. The Tsyganenko's magnetospheric field model and the Alexeev's paraboloidal magnetospheric model are used to compare the conjugate geomagnetic phenomena in both the Northern and Southern polar regions.

OPTICAL SIGNATURES OF TRAVELLING CONVECTION VORTEX EVENTS

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The optical signatures in the dayside aurora observed at Svalbard, Norway, have been observed during the propagation of three travelling convection events (TCVs) across the meridian of the observation point. All TCV events were associated with the occurrence of a wave in the auroral luminosity, which was realised in a travelling bulge at the equatorial edge of the cusp/cleft 630.0 nm auroral emission band. The bulge propagated westward or eastward at approximately the same velocity as the TCV and reached several degrees of latitude in amplitude. The equatorial border of the red emission band seemed to be shifted poleward in the center of the TCV event and equatorward at the leading edge (in the morning sector) or at the trailing edge (in the evening sector) of the event. The auroral luminosity wave may be associated with the excitation of discrete auroral forms which are also shifted poleward in the center of the TCV event and reappear equatorward of the previous location of the equatorial edge of the cusp/cleft auroral red emission band, near the region of the upward Birkeland current. The poleward shift of the cusp/cleft auroral red band and discrete auroras in the center of the TCV event may be interpreted as the result of a displacement of the equatorward boundary of the LLBL/PSBL by the electric field of the TCVs, associated with strong poleward convection flow in the center of the event.

ION COMPOSITION IN THE HIGH-LATITUDE NIGHTSIDE MAGNETOSPHERE: A STATISTICAL STUDY

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After almost two years of the POLAR mission, we have obtained a comprehensive set of data from the Magnetospheric Ion Composition Spectrometer (MICS). MICS is a subsystem of the CAMMICE experiment and measures the flux of various ions in the energy range of 1 - 400 keV per charge by means of an electrostatic analyser, a time-of-flight system, and a solid state detector. Using this data base we have conducted a statistical study on the abundance of various ion species in the high-latitude nightside magnetosphere. Previous works suggest that energetic oxygen ions play a fundamental role in the initiation of magnetospheric substorms. We will therefore focus our analysis on the oxygen contribution in the various plasma regimes and delineate between ionospheric and magnetotail sources. We discuss the dependence of the composition on geomagnetic activity and solar wind conditions.

CLUSTER MULTIDIMENSIONAL CLASSIFICATION OF GMS MAIN PHASES

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The work is devoted to investigation of the main phases(MP) of 31 GMS (geomagnetospheric storms) using pattern recognition methods: under analysis is the fact what of greater importance if for "external" classification of GMS-scales of changes (average level and variation range) of the leading basic characteristics(Dst- and AE-index,By- and Bz-component of IMB -B) or their character not depending on scale. It will be shown that both the classifications proves to be effective for GMS MP,but in different aspects-according to inner "similarity" or processes inner "correlativity".The analysis of the separated in various classifications GMS groups according to the peculiarities of their inner structures permitted not only specifying different variants of GMS MP procedure,but also underlying significant local interconnections originating during quick change of the parameters obtained at analysis of the second time derivatives of all 32 parameters involved to investigation. The content physical analysis of the (Dst- AE- Bz) - classification dendrites allows differently (than previously) to address the problem of storm-substorm relationship.

INVESTIGATION OF DAYSIDE AND NIGHTSIDE IONOSPHERIC RESPONSE DELAYS TO CHANGES IN THE IMF CONDITIONS USING SIMULTANEOUS SATELLITE AND EISCAT DATA

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This paper presents a multi-instrument study of the processes occurring between the interplanetary magnetic field and the Earth's ionosphere. The coupling of these two regimes leads to many observable features, not least of which is the generation of flow patterns in the high latitude ionosphere. The database created for the following study used the IMP-8 spacecraft and the EISCAT 'CP-1' experiment to provide the IMF data and vector flow velocities, respectively. Approximately 450 hours of simultaneous data has been accumulated spanning from 1993 to the present day. The entire data set was separated into two hour intervals so that a cross correlation study could be undertaken between the IMF B_z component and positive eastward and positive northward vector velocities, respectively. This statistical analysis highlights the response times for the ionosphere after changes in the IMF cause reconnection at the nose of the magnetosphere. The results from this study cover all local time, though special care must be taken when attempting to accurately determine nightside response times since many other features can be present, such as spatial discontinuities and substorm activity.

On the Magnetic Unconjugation of Travelling Convection Vortices.

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A three-dimensional model has been elaborated for the electric current system of high-latitude dayside magnetospheric convection vortices. The model takes into account the spatial distribution of the ionospheric conductivity as dependent on season, local and universal time. The model was applied to evaluate the field-aligned currents, transverse ionospheric currents and the ground-observed magnetic effect. (The latter is obtained in the terms of the equivalent ionospheric currents.) It is shown that the equivalent ionospheric currents features strongly depend on the ionospheric conductivity spatial distribution. Also, it is shown that the difference in the ionospheric conductivity of the Northern and Southern hemispheres leads to strong unconjugation in the positions of the Hall ionospheric current foci. In the light of the obtained results, the problem of the TCV's magnetospheric sources localization is discussed.

Detailing of physical picture of 22 March, 1979 geomagnetospheric storm (substorm) with using system approach (pattern recognition methods)

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We have carried out the physical picture detailing of complex geomagnetospheric (22 March, 1979) storm on the base of the comparing one-hour averaging data (global physical structure) and 5-minutes averaging data (detailed physical structure) with using more adequate to this phenomenon of system approach and pattern recognition method. Most sutable and informative for describing storms were system units characterized by the AE- index elementarysplashes with using formal criteria of apportionment most probable variant processes development as a whole. Detailing of storm physical picture taking into account delay time of the "effects" processes relative to the "cause" processes and with the inclusion one processes insted of exclusion of others allows to enlarge entire picture of a phenomenon and to reveal some aspects of interacrion interplanetary medium magnetosphere-ionosphere-geomagnetic activity. It has been shown that the storm traditional forecasting (the geomagnetic parameters on the base of the SW parameters) is not correct. The suggested system approach is more effective. It allows: a) to reveal the multi-chanel development of the processes. realizing different mechanisms, b) to base on the storm forecasting on some parameters comp[lex derived from calculated parameters and chooced on the SDA base the delaytime values of the AE-, AL-, Dst- indexes relative to the SW parameters.

STATISTICAL PATTERNS IN CHANGES OF SOLAR WIND AND IMF FOR SPACECRAFT ERA AND PLANETARY GEOMAGNETIC ACTIVITY

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Experimental data on plasma and IMF got during space era (1965-1996) from King's catalogue are analysed to find connection between changes of the geomagnetic activity and the solar wind parameters on annual scale. Ap index is used for character of the geomagnetic activity that classified into quiet (q), moderate and geomagnetic storm (d) levels according to the observed index. Solar wind data and IMF caused these geomagnetic conditions are classified also to q, d levels. It is shown that during transition of the planetary magnetosphere from q to d level such annual parameters of the solar plasma as velocity V, temperature T, mean module of IMF IBI increase; latitude angle of IBI Fi (GSE SC) and Bz IMF (GSE, GSM SC) demostrate turn of the IMF from north direction to the south. It is shown that the greatest relative change for the transition from g to d level have Bz IMF. Numerical values of the geoefficiency of the plasma parameters and IMF are defined and discussed.

THE RELATIONSHIP OF HF RADAR BACKSCATTER TO THE ACCUMULATION OF OPEN MAGNETIC FLUX PRIOR TO SUBSTORM ONSET

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We identify a characteristic signature observed in data from the Halley HF radar during the substorm growth phase and investigate what this reveals about magnetotail evolution leading up to substorm onset. The signature is a super-diurnal equatorward propagation of the radar backscatter returns. Solar wind spacecraft data helped to estimate the start of the growth phase, whereas geostationary spacecraft data or ground magnetometer pulsation data established the time of substorm onset. It is found that the signature in the radar data is characteristic of a particular class of substorm activity, those substorms which are the first to occur following quiet magnetospheric and ionospheric conditions. By using the solar wind data, we are able to estimate the reconnection electric field at the magnetopause for four such events. An empirical relationship is found to exist between the time integral of this electric field during the growth phase and the equatorward propagation of the HF radar backscatter. By relating this to the addition of open magnetic flux to the polar cap, an upper limit to the length of the reconnection X-line can be quantitatively estimated. Other possible interpretations of this relationship are discussed.

LOCAL POLAR MAGNETOSPHERE-IONOSPHERE TOPOLOGY DETERMINED BY ULF WAVE SIGNATURES USING AN ANTARCTIC MAGNETOMETER ARRAY.

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A closely spaced (~150km separation) triangular induction magnetometer array operated in Antarctica at high latitudes (L=14.2) near the open/closed field line boundary has been used to determine the latitudinal position of the cusp/LLBL projection onto the ionosphere relative to the array. Geomagnetic field line resonance (FLR) signatures in the Pc5 1-10 mHz range have been observed and their presence or absence is a diagnostic of closed/open field line status within the effective field of view of the array. It is expected that the FLR signatures will be present when the cusp/LLBL projection is poleward and the array is under closed field lines. Similarly, FLR signatures will be absent when the cusp/LLBL projection is equatorward and the array is under open field lines. ULF isotropic fast mode waves are also observed by the array as geomagnetic pulsations in the Pc1-2 (0.1-0.5 Hz range), probably as a result of mode conversion of field guided Alfven mode ion-cyclotron waves from the outer magnetosphere. We observe the presence of FLR signatures in the data when the Pc1-2 sources are poleward of the array and when there are no FLR signatures, Pc1-2 sources are equatorward of the array.

ELECTRON-PROTON PRECIPITATION EFFECTS ON THE IONOSPHERE DURING FAST/EISCAT/ESR COORDINATED EXPERIMENTS

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We have examined data obtained from several coordinated experiments between the spacecraft FAST and the radars EISCAT and ESR. These coordination periods include different levels of solar activity. The particle fluxes measured by FAST are used as inputs in a coupled electron/proton transport code, and the computed ionospheric parameters are then compared to the EISCAT measurements. We compare the effects of the electron precipitation to the ion precipitation, and show that ions can be a major source for the creation of the ionosphere. We will also describe the differences observed in the precipitation characteristics and resulting ionospheric conditions above EISCAT and ESR.

Statistics of cusp and magnetosheath ion populations observed with Polar.

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Magnetosheath ion populations are frequently observed by Polar as it passes through the region of the dayside cusp. With nearly two years of Polar/CAMMICE data now available we can begin to draw statistical conclusions on the occurrence and duration of these events. We associate them with interplanetary magnetic fields, as observed by Wind. Depencencies of the occurences of these ion populations with Bz and By are observed. The expected features are seen, namely a proponderence of events at lower invariant latitude during times of negative Bz, and to the dawn-side during negative By. There is however considerable scatter. Longer events are not invariably associated with Bz positive.

STS

DISPERSIVE PROTON INJECTIONS AT HIGH LATITUDE, OBSERVED BY INTERBALL AURORAL PROBE ON JANUARY 11, 1997

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While the plasma cloud of the January 1997 CME event was passing by the Earth, the Interball Auroral Probe was skimming the poleward edge of the duskside auroral oval. The PROMICS-3 plasma instrument observed dispersive injections of magnetosheath-like ions (mainly protons) over a wide range of magnetic local times (16-21 MLT). The ion injections were observed at exceptionally late local times, after a period of prolonged (8 hours) northward IMF. During the first injection, also oxygen ions was seen, and the same oxygen ions were also seen on conjugate field lines at an higher altitude by the TIMAS instrument on board the Polar spacecraft. The proton injections exhibited typical dispersive behavior, enabling to make estimates of their source with model calculations.
We present analysis of the event and discuss possible mechanisms producing observed injections, as well as source regions of the ions, as deduced from model calculations.

ELECTRIC FIELD CHARACTERISTICS OF THE HIGH-LATITUDE MAGNETOPAUSE

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Our survey of Key Parameters from the Magnetic Field Experiment shows that during first year of POLAR mission a distinct, high-shear magnetopause (MP) was crossed near the apogee on 22 orbits under high solar wind dynamic pressure (3.6 to 16 nPa). The majority of high-shear MP crossings occurred during northward interplanetary magnetic field (IMF) at the poleward edge of the cusp. There are also observations of a high-latitude MP under southward IMF when BY was a dominating component and these MP crossings took place on the evening or morning edge of the cusp. The geocentric distance of the observed magnetopause was always less (up to 2.5 R_E) than is predicted by the Tsyganenko 96.01 magnetosphere model. The above result suggests that either the whole magnetosphere at high latitudes is more compressible than it was found from low-latitude MP observations or that the high-latitude magnetopause is significantly eroded near the antiparallel merging site. We analyse the DC electric field measured by EFI while approaching the magnetopause. The pattern of the electric field should be different in these two situations.

CUTLASS FINLAND RADAR OBSERVATIONS OF THE IONOSPHERIC SIGNATURES OF FLUX TRANSFER EVENTS AND THE RESULTING PLASMA FLOWS

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The CUTLASS Finland radar has been run in a two-beam special scan mode, which offered excellent temporal and spatial information on the flows in the high-latitude ionosphere. A detailed study of one day of this data revealed a convection reversal boundary (CRB) in the CUTLASS field of view on the dayside, the direction of plasma flow either side of the boundary being typical of a dawn-cell convection pattern. Poleward of the CRB a number of pulsed transients are observed, seemingly moving away from the radar. These transients are identified here as the ionospheric signature of flux transfer events (FTEs). Equatorward of the CRB continuous backscatter was observed, believed to be due to the return flow on closed field lines. The two-beam scan offered an unparalleled opportunity to determine the size and velocity of the ionospheric signatures associated with flux transfer events and the related plasma flow pattern. The transient signature was found to have an azimuthal extent of approximately 1700 km and an poleward extent of ~250 km. The motion of the transient signature was in a predominantly westward azimuthal direction, at a velocity of 7±4 km s^{-1}.

BOUNDARY LAYER DYNAMICS AND SUBSTORMS VIEW FROM ISTP SPACECRAFT

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The kinetic energy of boundary layer plasma flows might be high enough for driving substorms. Plasma processes there could also control the onset of substorm activities. The mechanism of this interaction could be twofold: direct momentum exchange of the BL flows with PSBL/LLBL interfaces and generation of field-aligned current systems. The latters modify the ionospheric conductivity that might result in the cross-tail current desruptions and magnetic field re-configurations. We study the possible implications of the processes at high and/or low latitude flanks of magnetosphere on the basis of the recent experimental data provided by ISTP spacecraft. We concentrate on the MP encounters and plasma injections from the MSH deeply into the tail wich might initiate the substorm activity. We also study the reverse problem: the large scale distortions and motions of the magnetopause caused by formation and propagation of plasmoids. The chain: SW disturbances/ BLs/ substorms/ BLs is discussed along with the perspectives of the multipoint correlative substorm/BL studies.

VARIATIONS OF THE AZIMUTHAL COMPONENT OF IONOSPHERIC ELECTRIC FIELD BEFORE AND DURING AURORAL BREAKUP AS INFERRED FROM COORDINATED EISCAT AND TV MEASUREMENTS

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We discuss the results of the EISCAT measurements of the ionospheric electric fields near active auroral forms. We have examined six breakups near local midnight together with IMF data and have found the following features. 1) A westward component of the field gradually increases few minutes before a breakup. A negative turning of the IMF B_z approximately 30 minutes before a substorm onset seems to be a reason for this increase. 2) An aurora enhancement during breakup is accompanied by a decrease in the westward component of the ionospheric electric field from 30 to 5-10 mV/m. On the contrary, an auroral fading is accompanied by the recovering of this component approximately to the pre-breakup value. We assume a disturbance of ionospheric conductivity to be responsible for these variations. 3) An impulsive reduction interrupts the gradual increase of the westward component just before a breakup. This reduction coincides with a short-lived brightening of a pre-existing arc (pseudobreakup) and may be connected with a local enhancement of ionospheric conductivity, too. The observed features are discussed in the context of substorm development.

THE JANUARY 1997 CME AND ITS TERRESTRIAL IMPACT - AN EXAMPLE OF MULTI-INSTRUMENT STUDIES

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The coronal mass ejection of January 6, 1997 which caused a geomagnetic storm on January 10/11 was not an exceptional event from the solar/geophysical point of view. It was however the first event studied almost completely with a variety of instruments from its origin on the Sun to the effects in the terrestrial atmosphere. Observations with optical instruments on the SOHO space-borne observatory led to its detection, particle instruments on SOHO and on the WIND spacecraft monitored the properties of the corresponding magnetic cloud propagating through the interpanetary space, and several satellites within the terrestrial magnetosphere observed the results of the interaction of the latter with this cloud. Ground-based instruments finally registered the impact on the terrestrial ionosphere/atmosphere. Examples from the different measurements are presented and discussed. Such studies will in the future improve our understanding of solar-terrestrial relationships which is a prerequisite for reliable space weather forcast.

TIMING PSEUDO- AND TRUE- EXPANSION ONSET OF THE CDAW6 SUBSTORM OF MARCH 22, 1979.

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Timing of the well known CDAW6 substorm (10-13)UT of March 22, 1979 was performed in the series of earlier works (special issue JGR, 1985) using the diverse of traditional means but without data on the open magnetic flux variations. The first considerable (> 150 nT) substorm onset in 1054 UT was taken as expansion onset. According to NENL substorm model this moment determines start of the open tail reconnection. In this paper plots of the open magnetic flux variations, calculated by magnetogram inversion technique, will supplement traditional means of substorm timing. It will be shown that this additional information makes it possible to determine start of the open tail reconnection exactlier that changes the results of timing essentially. It is determined that true expansion onset is at 1124 UT but moment 1054 UT is the first of pseudobreakups during active interval (1054-1124)UT, i.e. it is substorm onset, which does not include the open tail reconnection. The interval (1054-1124)UT is separated as the additional active phase, preceding expansion.

ALFVÉNIC STRUCTURES IN THE OUTER CUSP

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Alfvén waves provide the basis for electromagnetic coupling between the ionosphere and the magnetosphere. Satellite measurements demonstrate that electromagnetic (Alfvénic) structures with spatial width down to an electron inertial length are observed at all altitudes: from topside ionosphere to the magnetopause layer. These structures are believed to be associated with discrete auroral forms and represent an interesting study subject in the magnetospheric physics. We analyze the electromagnetic field records measured by the Polar spacecraft in the outer cusp region and show that the Alfvénic structures are most likely produced by plasma structures penetrating from the magnetosheath.

INVESTIGATION OF SUBSTORM-ASSOCIATED FEATURES IN THE PLASMA SHEET OBSERVED BY THE POLAR SATELLITE

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This presentation details the initial results obtained from a study of two intervals of substorm activity observed by the Polar spacecraft during passes over the Scandinavian sector. The study makes use of the CAMMICE instrument on board the Polar spacecraft specifically to investigate substorm effects in the plasma sheet. Other Polar instruments from which data has been used include the Ultra-Violet Imager (UVI) that provides images of the auroral zone throughout both intervals. There are also several other instruments used including those on board the WIND, LANL and IMP-8 spacecraft, along with the IMAGE magnetometer chain. These instruments provide background data sets that are used to confirm the presence of substorm activity and give the timing of the onset of any such activity. The first interval is a period of low magnetic activity, with several apparent entries into, and exits from the plasma sheet as the spacecraft moves across L-shells ranging from L = 19 to L = 8. The second is a more magnetically active interval during which several substorms take place, with entry into the plasma sheet occurring well into the expansion phase.

DAYSIDE HIGH-LATITUDE IRREGULAR MAGNETIC PULSATIONS OF 2-10 MINUTES PERIOD, AND THEIR RELATIONSHIP TO THE SOLAR WIND.

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The occurrence of dayside high-latitude magnetic pulsations with periods between 2-10 minutes is investigated statistically using data from around 20 magnetic stations in Greenland, Scandinavia and Canada many of which has been in operation for a full solar cycle. We derive timeseries of the power spectral density in two different frequency bands: 2-4 minutes period and 5-10 minutes period. The average psd in these bands maximizes in the early morning sector between auroral and cusp latitudes. We have compared with satellite observations of the solar wind velocity, and find a high log-linear correlation in the range 0.7-0.9. The highest correlation is found in the 2-4 minute band. Contrary to this the correlation with Bz and Bs is very weak (~0.1). We further investigate the relationship to other solar wind parameters such as density, dynamic pressure and gardenhose/non gardenhose angle of the IMF.

SUPERDARN STUDIES OF THE IONOSPHERIC CONVECTION RESPONSE TO A NORTHWARD TURNING OF THE INTERPLANETARY MAGNETIC FIELD

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The response of the dayside ionospheric flow to a sharp change in the direction of the interplanetary magnetic field (IMF) measured by the WIND spacecraft from negative Bz and positive By, to positive Bz and small By, has been studied using SuperDARN radar, DMSP satellite, and ground magnetometer data. In response to the IMF change, the flow underwent a transition from a distorted twin-cell flow involving antisunward flow over the polar cap, to a multi-cell flow involving a region of sunward flow at high latitudes near noon. Sunward flows were found to appear immediately (within a minute or so) at the start of the flow change, localised initially in a small region near noon at the equatorward edge of the radar backscatter band. Subsequently the region occupied by these flows expanded rapidly east-west and poleward over intervals of ~7 and ~14 min respectively, to cover a region at least 2 h wide in local time, and 5 deg in latitude, before rapid evolution ceased.

APPLICATION OF COLLECTIVE WAVE SCATTERING TO SUPERDARN RADARS : SPATIO-TEMPORAL EVOLUTION OF TURBULENCE PARAMETERS FOR SPECIFIC GEOPHYSICAL EVENTS

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The collective wave scattering theory, associated with a Lagrangian description of the diffusion center motion, has been applied to the analysis of multi-frequency HF coherent radar data. An analytical expression to fit the power of the autocorrelation functions has been established, that allows a direct determination of the various characteristic parameters of the ionospheric turbulence : turbulent diffusion coefficient, correlation length and correlation time. We present spatio-temporal evolutions of the turbulent diffusion coefficient for specific events caracterized by a divergent plasma flow. Three different regimes are well identified. The whole picture is in agreement with hypothesis made from the macroscopic behaviour and morever helps to discriminate between different possible scenarios. This is to our knowledge the first attempt to use the theory of collective wave scattering for a better understanding of the ionosphere-magnetosphere coupling.

Polar Cap Boundary Layer Waves, Ion Heating and Magnetic Storms

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The Polar plasma wave instrument team has identified "broadband" plasma waves adjacent to the polar cap magnetic field lines. We call these dayside emissions polar cap boundary layer (PCBL) waves. These emissions are almost always present on field lines that map into the dayside magnetopause low latitude boundary layer (LLBL). These LLBL waves, through wave-particle resonant interactions, can cross-field diffuse magnetosheath plasma to form the LLBL plasma region.

We use high resolution wideband waveform data to investigate the nature of the "broadband" PCBL waves. Both the electric and magnetic components have been studied. We will comment on the nature of the waves (electromagnetic or electrostatic, time variability, etc.) and how they comprise the apparent broadband structures.

The waves appear to be responsible for the heating and acceleration of H^+, He^+, He^{++} and O^+ ions. We argue that the O^+ ions will be preferentially heated due to the wave spectral shape (steeper than f^{-1}). We propose that these PCBL ions could be the seed population for the magnetic storm ring-current.

STRONG FLOW BURSTS IN THE NIGHTSIDE IONOSPHERE DURING EXTREMELY QUIET CONDITIONS

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Results of an HF radar study of convection during an extended magnetically quiet interval on March 10 1997 are presented. After thirty hours during which the solar wind met the criteria for a quiet magnetosphere the HF radars at SANAE and Halley in Antarctica showed strong activity on the night side. Flow bursts with velocities of more than 2000 m/s, corresponding to electric fields exceeding 100 mV/m, were observed. These occurred quasi-periodically for almost two hours on the night side with a repetition time of several minutes. It is concluded that they map to a region well inside the magnetotail. It is suggested that they are associated with sporadic energy releases during reconfiguration of the tail magnetic field, and that this can occur even during an extended quiet period. ISTP spacecraft data will be presented to try and understand the energy coupling processes involved.

COMPARISON OF PREDICTIONS BETWEEN DIRECT ENTRY CUSP MODELS AND RECONNECTION CUSP MODELS

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One big issue concerning the origin of the cusp particles is the relative importance of so called "direct entry" and so called "reconnection." In the reconnection models the magnetosheath plasma receives bulk acceleration at the magnetopause whereas the plasma does not receive too much acceleration but is rather decelerated in the direct entry models when it penetrates from the magnetosheath to the magnetosphere. The deceleration force is not necessarily the $\mathbf{J} \times \mathbf{B}$ force but rather the compression due to the geometry and the escaping ionospheric ions. The problem is that both models expect very similar cusp particle features because the injected ions are affected by the wave activity, thermalization, energization and the magnetospheric electric field (both parallel and perpendicular) between the entry region and the magnetospheric cusp. For example, the direct entry model predicts energization of the plasma especially at the boundaries of the cusp. Whenever reconnection-based simulations succeed to reproduce some features of the cusp plasma, they automatically become the QUANTITATIVE evidences for the direct injection model too. Therefore, we have to really look into the QUALITATIVE difference between the predictions of two models.
many forms and the wave activity and turblence is highest in the cusp, so that case studies are too much misleading because one may found almost all evidences for any types of model from a single case. Therefore we have to carefully select the examples of cusp that shows the general features for the examination of the models.

ENERGETIC OXYGEN BEAMS IN THE PLASMOIDS WITH BOTH B_Y AND B_Z BIPOLAR MAGNETIC FIELD SIGNATURES

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Energetic O^+ ions from the Earth polar ionosphere were often seen in the of plasmoids which showed both B_y and B_z bipolar signatures. The plasmoids structures with oxygen bursts are closely related to substorms and can be understood as a direct product of the substorm process. The energetic O^+ bursts exhibit strong beam-like structures, and are embedded in plasma flowing tailward at very high speeds (exceeding 1000Km/s). A clear dawn-dusk gradient anisotropy and energy dispersion are exhibited in the those bursts. The energy dispersion in the oxygen bursts allows us to estimate the position of the acceleration source (presumably the Near Earth Neutral Line -NENL position).
The global aspect of the acceleration and transport of oxygen ions are discussed. The physics implications of the both By and Bz bipolar magnetic field signatures and the role of boundary layers of those plasmoids will be also addressed.

ST9 Effects of geomagnetic storms and high-energy particle events on the ionosphere, thermosphere, and middle atmosphere

Convener: Lastovicka, J.
Co-Convener: Förster, M.

THE SIGNAL OF SOLAR/GEOMAGNETIC ACTIVITY IN THE STRATOSPHERE OVER EAST-SIBERIAN AREA.

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Since East Siberian region is the area of special interest for the global distribution and temporal variation of ozone due to climatic peculiarities and record low ozone values during some winters we analysed a possible response of the stratosphere (total ozone content, TOC) to the variations of solar and geomagnetic activity (geomagnetic activity, Solar Proton Events (SPE), major geomagnetic storms and sudden winter stratospheric warmings) over Irkutsk meridian (104E). We have found some statistically significant correlations with geomagnetic activity for TOC during E-phase of quasi-biennial oscillation (QBO). There is a tendency of the effect of major geomagnetic storm to be positive and to be different for E- or W-phase of QBO or for location of ozone observations. The effect of SPE in the TOC exists as well, but depends on the intensity of particle flux and season. Intensity and behaviour of the total ozone response to stratospheric warming depend on the latitude of ozone observations and on type of warming.

EFFECT OF GEOMAGNETIC STORMS ON THERMOSPHERIC NEUTRAL DENSITY AND WAVE ACTIVITY

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The reaction of the neutral upper atmosphere on geomagnetic heating is demonstrated through two phenomena: one of them is the variation of the atmospheric density, the second is the changing character of the wave pattern, present in the upper atmosphere, during geomagnetically disturbed days with respect to quiet periods. In the first case density values were derived from CACTUS micro-accelerometer measurements, while in the second case the investigation of the wave activity was based on the San Marco V accelerometer data as well. Since the geomagnetic term of the CIRA'86 (MSIS'86) model proved to be a double valued function of Kp (Ap), a model correction was suggested with an added Dst-dependent term. The new dMSIS model, based on the measurements of a quasi equatorial satellite, refers to the equatorial zone and hints at the existence of an equatorial heat source in addition to the auroral heating. As regards the wave activity in the thermosphere, our investigation demonstrated that the average deviation of the model residuals (representing the mean wave-amplitude) changes with the level of the geomagnetic disturbances, e.g. being higher in quiet periods at high altitudes.

EFFECT AURORAL PRECIPITATION ON THE GLOBAL NITRIC OXIDE DISTRIBUTION IN THE LOW THERMOSPHERE

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On the basis of Global Self-consistent Model of the Thermosphere Ionosphere and Protonosphere (GSM TIP) was constructed the block of odd nitrogen with appropriate chemistry and 3-D transport of the minor neutral constituents NO, N(2D), N(4S). The calculat ions were performed for the summer solstice and high solar activity and moderate geomagnetic condition. The geomagnetic disturbance was simulated by increasing of auroral electrons flux, which was changed on a factor 30 from quiet level. The centre of ion isation rate was located on 70 latitude and 24 MLT. It was shown, that even the short-term strengthening of auroral electron flux (in our simulation ~ 1 hour) results in formation ring zone of increased NO density in auroral area at 100 km. It should be n oticed also, that the spatial distribution of increased NO density is different from geometry precipitating. The scale time of this zone is about days, and [NO] can increase midlatitude level in 5-10 time. The behaviour NO during disturbance at 120 km an d over is controlled by variation of the ionisation rate. Result of numerical simulation suggest, that the significant growth of [NO] then does not result in downturn of neutral temperature afterwards of activity period, and accordingly to consequences i n global distributions of other parameters of upper atmosphere. The possible cause of these phenomenon is discussed.

TEMPERATURE-PRESSURE DEVIATIONS AND PREVAILING WINDS IN THE N.H. WINTER TROPOSPHERE IN YEARS OF HIGH AND LOW GEOMAGNETIC ACTIVITY

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Tropospheric temperature and pressure fields as well as prevailing winds on the Northern Hemisphere in the winter periods 1952-1997 were investigated. Composite maps created for the high and low geomagnetic activity and individual QBO phases show clear differences not only between different levels of geomagnetic activity, but also between the two phases of QBO. Special attention was given to the behaviour of the lower troposphere in January and February 1982.

F1 REGION ELECTRON DENSITY PROFILES DURING GEOMAGNETIC STORMS AS MEASURED AT PRUHONICE

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Based on analysis of ionosonde measurements at Průhonice (50N, 15E), ionospheric effects of four geomagnetic storms from 1986, 1994 and 1995 (low solar activity) are analysed. The electron density profiles derived from ionograms by POLAN are studied with a special emphasis paid to F1 and F2 layer behaviour. The F1 layer appears to be rather stable during geomagnetic storms with no significant changes. The pattern of B1 and Bo variation during geomagnetic storms is shown. A diurnal asymmetry of the effect in F2 layer is illustrated, the storm negative effect in NmF2 being much stronger in morning than afternoon hours.

MODELLING THE EFFECTS OF GEOMAGNETIC STORMS ON THE IONOSPHERE/THERMOSPHERE SYSTEM

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Important progress has been made recently in developing the theory of geomagnetic storms for the thermosphere and ionosphere. Numerical simulations have provided a better understanding of the dynamics of the upper atmosphere and have permitted the identification of the processes responsible for first order global storm effects. Geomagnetic storms arise from a large increase, often associated with changes in the spatial distribution, of the high-latitude energy deposition from the magnetosphere. The changes in energy input have global consequences. Wave surges, driven by the impulsive energy input, propagate and interact globally, and are dependent on Universal Time (UT) and the time history of the source. There is a strong preference for wind surges to maximize on the nightside and in the longitude sector adjacent to the magnetic pole. Equatorward wind surges drive F-region plasma upwards and can initiate a positive ionospheric change. The divergent nature of the wind field causes upwelling and changes to the neutral composition, that can be transported by the storm and background wind fields. Negative ionospheric phases result from increased molecular species. At low latitudes electrodynamic changes are initiated by penetration of magnetospheric fields followed by rapid shielding. The electrodynamics proceeds through a sequence of reactions lasting more than a day. In this paper we present the latest results in thermosphere/ionosphere storm modelling and review some of the open questions.

STUDY OF THE TRAPPED RADIATION DEPENDENCE BY THE NEUTRAL ATMOSPHERE VARIATIONS AT THE ALTITUDE OF THE MIR SPACE STATION

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Measurements on board the MIR space station by Bulgarian-Russian dosimeter LIULIN have been used to study the Earth radiation environment dependence by the neutral atmosphere density and composition. It is found that the proton fluxes in the inner magnetosphere, which formed the cosmonaut doses inside of MIR space station, are in strong dependence by the altitude, season, universal time and the phase of the solar cycle. This dependence was attributed to the neutral atmosphere density variations at the altitude of the station. The obtained simple equations are able to be used for prediction of the cosmonaut doses during the flight of the International Space Station which will flow on a similar orbit attitudes.

ELECTRODYNAMICS OF AURORAL ARCS DURING VARIOUS PHASES OF A SUBSTORM

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The electrodynamics of auroral arcs are studied for the various phases of two substorm events which occurred during a multi-instrument campaign on 13-14 Feb 1996. The data sets were provided by EISCAT, Sussex and MPI all-sky cameras, and the IRIS riometer. The issues considered are the concurrency of absorption and optical signatures, classification of auroral arcs, and the study of the evolution of a number of physical parameters including temperatures, conductivies, and electron precipitation spectra at E and F region heights. EISCAT-measured $E \times B$ velocities are compared with estimates of arc velocity from the optical, and riometer drift measurements. IRIS tracks several patches of intense ionisation which drift southeast until the appearance of a magnetic bay, when optical activity to the south of Tromsø – associated with the signatures still present in the IRIS data – becomes visible. On one event, the magnetometer shows an enhanced electrojet crossing the EISCAT at Tromsø accompanied by arcs moving north-south.

MODELING THE EFFECTS OF FORBUSH DECREASE IN GALACTIC COSMIC RAYS ON OZONE CONTENT

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The two-dimensional dynamic-chemical model is used to examine contributions of three possible mechanisms of galactic cosmic rays (GCRs) effects during Forbush decrease on the nitric oxides NOx, which influence on ozone through catalytic cycles. 1) An effect of atomic nitrogen N, produced by GCRs ionization and dissociation processes, on NOx production and destruction; 2) an effect of temperature profile changes, that lead to vertical transfers of atmospheric gaze and to increasing of nitric oxides ooncentration at altitudes where GCRs penetrate their energy; 3) an impact of GCRs effects on a rainout rate of NOx due to decreasing of rain precipitations. The results show the latest is most significant mechanism. The computations allow to substantiate an ozone depletion at altitudes about 10-13 km observed in the periods of Forbush decrease maximum.

GEOMAGNETIC STORM EFFECTS ON THE TOPSIDE IONOSPHERE AND PLASMASPHERE

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The coupled ionosphere–thermosphere–plasmasphere system is a very complex one. The study of its interrelationship during geomagnetically disturbed conditions is an especially challenging task. A significant progress has been achieved during the last years in developing comprehensive theoretical models to describe its global behaviour. But also more simple, specialized numerical modelling of some special aspects of storm behaviour and/or regional models have been contributed to the progress in this field. The paper tries to summarize the recent development of upper ionosphere and plasmasphere storm studies and modelling. From an observational point of view the upper ionosphere/plasmasphere region is well pronounced in radio beacon measurements providing the total electron content (TEC). In recent time space-based radio navigation systems such as GPS offer new opportunities to derive TEC on regional and/or global scale. Combining TEC with ionosonde data, the variability of the shape of the electron density distribution during storms can be studied. We present some examples of co-ordinated investigations, as, e.g., the CEDAR storm study intervals.

GLOBAL TOMOGRAPHY DURING IONOSPHERIC STORMS USING GPS DATA

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We present in this work the evolution of the 3-D electron density at global scale during two ionospheric storms (October 18-19, 1995 and January 10, 1997) computed using only actual Global Positioning System data. The tomographic model is solved by means of a Kalman filtering with a filter updating time of 1 hour in a Sun-fixed reference frame, and with a resolution of 10x10 degrees in latitude/local time and 100 km in height including also a protonospheric component (8 layers). The data set contains the data from the International GPS Service IGS (with more than 200 ground GPS stations worldwide distributed) and the GPS/MET low orbiting GPS receiver (both positive and negative elevation observations are used). This means for each storm 1,000,000 of delays, 400 *occultations* and 3,000 unknowns per batch. The International Reference Ionosphere (IRI) and data coming from ionosondes are used to demonstrate the reliability of the results.

Cluster analysis of strong geomagnetic storms

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Based on the cluster-regression analysis of 10 great (IDst maxI >100 nT) storm events occurring in 1978 - 1979, it is shown that the maximum value Dst
max is approximated more correctly by maximum values of the interplanetary magnetic field (IMF) parameters than by current ones . For enhanced magnitudes of the azimuthal electric field Ey, Akasofu's injection function
ε at the storm main phase, solar wind dynamic pressure, and the IMF magnitude (B), the Dst max value can be approximated by a simple expression: I dst max I = 43.6+7.6(I Bz max I _+ 1.6 . The magnitudes obtained by means of this regression equatio are in good agreement with Dst max magnitudes observed for 21 great magnetic storms during 1966 - 1988.

Influence of the Variation of some Helio-geophysical factors on Human Health

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To investigate the influence of the variations of 23 helio-geophysical factors on human health the regression analysis is used. The results give the main factors acting on the human health and add there effects. The main result show that 30 percent of the hospitalized patients are related to the diurnal variations of the helio-geophysical factors. The variations of the atmosphere pressure, the temperature and the wind are dominant factors. The changes of the IMF polarization activate 11 - 31 percent of the analysed cases. Thes phenomena were explaind with the absence of the Pc3 pulsations during this period.

ENERGETIC ELECTRON PRECIPITATION AS A SIGNATURE OF COLD PLASMA STRUCTURE NEAR PLASMAPAUSE

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The influence of cold plasma structure in the magnetosphere on energetic electron precipitation is investigated using plasma and wave measurements made on board the Intercosmos-24 satellite. The localized energetic electron precipitation were found, related to electron density inhomogenities near plasmapause in the evening sector. These electron precipitations were observed during reconstruction of the outer plasmasphere on account of enhanced magnetic activity. The spatial coincidence of localised electron precipitation with ELF/VLF emissions occurrence or there intensification indicate that the probable precipitation mechanism is the cyclotron wave-particle interaction in the region of enhanced plasma density. This type of electron precipitation can be eventually used for fine cold plasma diagnostic of outer plasmasphere in the evening sector during the magnetic disturbance.

THE GEOMAGNETICAL ACTIVITY EFFECTS IN THE GLOBAL TIDAL STRUCTURE OF THE THERMOSPHERIC WIND

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The global numerical model was used in the calculations of the tides and mean state thermosphere by the different amplitude of the cross polar cup potential (CCP). The latitude dependence of the mean zonal uniformity wind, the amplitudes and phases of the zonal harmonics mean wind, solar migrating and nonmigrating diurnal and semidiurnal tides were obtained from the calculating global diurnal variations of the thermospheric parameters using the Fourier transformation technics. The results of the calculations are summarized as follows: 1. The zonal uniformity westward wind increase with increasing CCP at all latitudes, the zonal uniformity equatorward wind increase at the high latitude only. The amplitudes of the zonal harmonics with m = 1,2 in the mean wind increase with increasing CCP. 2. The diurnal tide perturbations localized at the high latitudes. The nonmigrating tides have the significant contribution in the lower thermosphere diurnal tide. The nonmigrating tides amplitude increase with growth the CCP. At the upper thermosphere the diurnal tide is independent on the longitude. 3. The semidiurnal tide structure is determined by supperposition of the solar and nonmigrating tides. The semidiurnal wind amplitude decrease in the lower thermosphere with increasing the CCP. The perturbations of the nonmigrating tides are complex. There are some tides with the increasing and decreasing amplitudes.

SPATIAL IRREGULARITIES IN THE MID-LATITUDE IONOSPHERIC STORM REACTION AND ITS THEORETICAL MODELING

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One of the main difficulties in modeling the ionospheric reaction on the geomagnetic disturbances is the great variability, or so called "irregularities" in this reaction, depending on season, local time, latitude, longitude, etc.. Additional problem in treating this phenomenon arises from the fact that during magnetic storms the quantity of ionospheric data strongly decreases. So the standard statistical methods become unusable to describe the spatial distribution of ionospheric parameters.

We suggest a qualitatively different approach to solve this problem - 1. an hourly values of foF2 and hmF2, calculated by an "aeronomical" ionospheric model are compared with the measured values of these parameters; 2. if the differences between measured and calculated values become significant, a special created procedure starts that allows updating the input aeronomical parameters in our ionospheric model (vertical plasma drift and neutral composition); 3. the last step is calculating the spatial distribution of foF2 and hmF2 over the globe (in latitudinal range: 35^0-65^0), or over smaller restricted area.

Comparison between model's spatial distribution over the area: Lat= (35^0-65^0), Long=(0^0-90^0) and Re-data for the storm-time period: 10-11 October 1988 gives very hopeful results.

LOW LATITUDE ENHANCEMENTS OF EXOSPHERIC ATOMIC HYDROGEN COLUMN ABUNDANCES FOLLOWING GEOMAGNETIC STORM ONSET

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Measurments of the atomic hydrogen Balmer-alpha (656.3 nm) emission at the Arecibo Observatory reveal that two-fold enhancements of the atomic hydrogen column density commonly occur following magnetic storm onset. Three individual storms are studied, and each are correlated with approximately twofold enhancements of the H column abundance following within 48 hours of storm onset. Precise timing is difficult to discern from these observations that are limited to the nighttime. Nevertheless, the detected enhancements can not be explained by simple thermal expansion of the thermosphere, which accounts for only 7% - 15% of the column enhancement during the storms. Also, the twofold enhancements we measure are exactly contrary to H column reductions predicted by MSIS-86. We conclude that the measured low latitude enhancement are the consequence of H transported to Arecibo, most likely meridionally from higher latitudes.

EFFECTS OF THE IONOSPHERIC CONVECTION ON THE NEUTRAL WINDS IN THE LOWER THERMOSPHERE

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Numerical calculations of the thermospheric and ionospheric parameters at the altitude range 80-520 km were obtained for the summer solstice and high solar activity. The Global Self-Consistent Model of the Thermosphere, Ionosphere and Protonosphere (GSM TIP) was used. The numerical results were obtained with a self-consistent calculation of the electric fields of the magnetospheric and dynamo action origin for the two cases associated with quiet (Kp~0) and moderate (Kp ~ 3-) geomagnetic conditions. The numerical calculation results of the neutral wind system at the 120-140 km are presented. It was found that in the case of the two-cell shape and a symmetric potential drop from down to dusk magnetospheric convection, associated with Kp ~ 0 (10 kV) wind velocities have a clear diurnal variation and mainly zero average values on the time at the all over latitudes. In the second case, associated with Kp ~ 3+ (50 kV) the two-cell ionospheric convection pattern was shifted to the midnight sector. It are shown that space variation and increasing of the ionospheric convection causes initiation of the semidurnal variation of the zonal wind component at the high latitudes. arising of the westward zonal average wind at the high and middle latitudes. and doesn>t practically change parameters of the meridianal wind component. The modification of the wind system at the low latitudes are small under the study conditions.

DYNAMICS OF THE F-REGION DISTURBANCES DURING GEOMAGNETIC STORMS

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Data from three meridional chains of ionosondes (Europe, East Asia and Australia) are used to analyse the dynamics of F-region disturbances during geomagnetic storms. The relative to medians variations of foF2 are used to generate Lat/UT plots for every meridional chain. These plots visualize the time development of ionospheric disturbances as they move equatorward from the auroral regions. The average value and the meridional gradient are found to represent satisfactorily the latitudinal shape of the disturbances at any fixed moment. The average value is modelled as a function of power index or Kp, as the respective constants in the expression are obtained by a regression fit for a large number of geomagnetic storms occurred between 1981 and 1995. The meridional gradient has a clearly expressed periodicity both inside and outside storms and it is analysed statistically to reveal its main features. Penetration of the disturbances to mid- and low-latitudes is a seasonal dependent. The plots of East Asian and Australian chains show clearly the transequatorial penetration of summer disturbances in winter hemisphere.

EFFECTS OF GEOMAGNETIC STORMS AND ATMOSPHERIC PROCESSES

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It is assumed that geophysical cycles of 7-9, 15-17 and 33 days can occur. Many of these cycles and shorter ones may be related to the respective solar activity cycles; for instance, the 27, 13-14, 9 or 6-7 days cycles can be found in all meteorological indices including the various atmospheric circulation indices. Simular cycles are also observed in the characteristics of the Earth's magnetic field disturbances. The 6 and 9 days rhythms is the Earth's atmosphere are assumed to be relatedto the sectorial structure of the IMF. The 9-day period corresponds to 19 sectors with three geoactive boundaries, while the 6-7 days cycle corresponds to 29 sectors with four geoactive boundaries.

Thus, the occurence of common "solar rhythm's" in athmospheric processes and in geomagnetic disturbunces may indicate thqt they arise from a common solar cause assosiated with the sectoral structure of the IMF.

Relationships of the lower atmosphere with the IMF and with solar wind were found in numerous works. The sign of the correlation between solar wind velocityand atmospheric parameters (pressure, air radiation, temperature, etc.) reverses when the Earth moves from one IMF sector to another.

ON THE DIRECT IMPACT OF THE SOLAR WIND DYNAMIC PRESSURE ON THE HIGH -LATITUDE IONOSPHERE,THERMOSPHERE AND MIDDLE ATMOSPHERE

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One prominent feature of the global magnetic storms and high-energy corpuscular events was ignored in the previous studies namely enchanced solar wind dynamic pressure. We present the experimental evidences that any notable rise of the solar wind dynamic pressure causes the synchronous disturbances in the high-latitude ionosphere, thermosphere and middle atmosphere. We checked this effect on various experimental data. We have found that the following parameters are proportional to the solar wind dynamic pressure: daytime maximum of ionization in the F-region: height of the stratopause, height of the maximum stratospheric ozone density: temperature of lower mesosphere and upper stratosphere. The effects can be explained in the framework of the modified global electric circuit with the Earth magnetosphere magnetopause as an external element.

OBTAINING THE IONOSPHERIC TOTAL ELECTRON CONTENT AT REAL-TIME UNDER HIGH GEOMAGNETIC ACTIVITY CONDITIONS

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Obtainig information at real-time about the ionospheric total electron content (TEC) under high geomagnetic activity conditions is the purpose of this paper. This magnitude has been estimated using the dual-frecuency carrier phases transmitted by the Global Positioning System (GPS) satellites. As it is well known, the GPS signals provide with two observables: the pseudorange and the more precise and less noisy carrier phase. The feature of this work is the capability to observe the variations of the TEC during a geomagnetic storm event from a GPS receiver station. For this purpose it has been necessary to implement algorithms that allow to detect and to correct the phase biases by an integer number of wavelengths at the same time that the data is gattered from the satellites. Precedent works that study the variations of the TEC in a geomagnetic storm at real-time, use differences of the GPS carrier phase observations separed one siderial day for the same pair of station and satellite. The advantage of the presented method is to do not necessary using this phase diferences to obtain the variations of the integrated electron density at real-time. In this work, the TEC variability during the January 1997 geomagnetic storm event has been estimated from a dual-frequency receiver station.

SOME F2-LAYER EFFECTS DURING JAN 06-11, 1997 CEDAR STORM PERIOD AS OBSERVED WITH THE MILLSTONE HILL INCOHERENT SCATTER FACILITY

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Daytime negative storm effect on Jan 10, strong NmF2 night time increase on Jan 7 and 8 followed by a strong T_e decrease down to T_n are discussed. Neutral composition and $T_n(h)$ were inferred from IS observations using a self-consistent approach to F2-layer modelling. Observed T_e, T_i, and N_e profiles were corrected for the disturbed day using the calculated ion composition. Calculated O/N2 ratio at hmF2 is less by a factor of 3.7 than MSIS prediction for Jan 10 and is close to MSIS for quiet days. Strong NmF2 night time increase by more than factor of 3 is due to observed E x B drift (westward E) moving plasma from higher L shells to lower ones and squeezing it into F2-region. Moderate $(2.2 - 2.7) \times 10^{12}\ m^{-2}s^{-1}$ fluxes in agreement with IS observations were shown to be sufficient to account for the night time NmF2 increase. Such fluxes are much less than usually considered about $10^{13}\ m^{-2}s^{-1}$. This NmF2 increase is the main reason for observed T_e dropping down to T_n (about 680 K) as it follows from the analysis of the energy equation.

STRUCTURE SPECTRUM VARIATIONS REGISTRATED IN INTENSIVE MAGNETIC STORM

European Observatories of the Middle Geomagnetic Latitude
S.J. Mihajlovic, M. Obradovic

In this paper, it have been shown the results of spectral analyze avriations of the geomagnetic field, registrated in intensive magnetic storm, 13. March 1989, on European observatories of the middle geomagnetic latitude. It has been shown microstructure of short periodic and long periodic part of spectrum variations, then microstructure D_{ST} and D_i variations, registrated in magnetic storm 13. March 1989, on observatories of the middle geomagnetic latitude.
On the basis of results of this analysis, the model microstructure of geomagnetic field variations, registrated in intensive magnetic storm, has been done. This model relates on observatories of the middle geomagnetic latitude.
The microstructure spectrum nonregular D_i variations models, registrated in intensive magnetic storm 13. March 1989, on European observatories of the middle geomagnetic latitude, is shown on figure 1.

EFFECTS OF HIGH-ENERGY ELECTRONS DURING GEOMAGNETIC STORM IN THE IONOSPHERE ON LOW L-SHELLS.

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Dynamic movement of high-energy electrons (spectral measurement of electrons E_e~0.04-2.0 Mev) on various L-shells into the Earth's ionosphere from satellites "Intercosmos-19" (500-1000 km) and "Cosmos-1686" (350-500 km) data is shown during several strong and intermediate magnetic storms. Basic attention is paid to the particles movement at on low altitudes and L-shells (L=1.1-1.5) and electrons precipitation in high thermosphere caused by pitch-angle diffusion. It was obtained that during the magnetic storm main phase the boundary of energetic particle registration shifts towards higher latitudes whereas the boundary of plasma registration shifts towards lower latitudes. The difference between dynamic and existing models is shown. An analytical connection for particle, wave and plasma parameters for various phases of the geomagnetic storm is obtained. Possible types of the wave-particle interaction during various storm stages were found. The role of high-energy electrons in D-layer ionisation, winter anomaly and others processes in the thermosphere and middle atmosphere are discussed.

DIFFERENT PHYSICAL MECHANISMS OF STRONG NEGATIVE F2-LAYER STORM EFFECTS OBSERVED WITH EISCAT

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Two periods of EISCAT observations comprising the very disturbed day Apr 03,1992 and Apr 10,1990 were analyzed with a self-consistent approach to the day-time F-region modeling. The NmF2 decrease by a factor of 6.4 on Apr 03 was produced by enhanced electric field (E ≈85 mV/m) and strong downward plasma drift, but without any noticeable changes in thermosphere parameters. The increase of the O+ + N2 reaction rate resulted in a strong enrichment of the ionosphere with molecular ions even at the F2-layer heights. The enhanced electric field produced a wide midlatitude day-time trough on Apr 03 which was different from the polarization jet events. The strong negative storm effect on Apr 10 with a complete disappearance of the F2-layer maximum was attributed mainly to changes in neutral composition and temperature. The calculated perturbation in the Tn(h) profile implies strong cooling of the lower thermosphere which may be due to increased nitric oxide concentration.

GEOMAGNETIC STORMS AND TOTAL OZONE

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Geomagnetic storms are supposed to affect the whole ionosphere-atmosphere system, at least at high and higher-middle latitudes. A brief review of effects of strong geomagnetic storms on total ozone content is presented with a special emphasis paid to effects observed near the latitudinal circle of 50N. At these latitudes, significant effects of geomagnetic storms on total ozone have been observed only in winter, very weak and statistically insignificant effects near equinoxes and no effects in summer. The effects have been significant only for strong storms, $A_P > 40$ or better 60, and only under very specific conditions – high solar activity and the east phase of QBO. The observed effects consist in redistribution, being best-developed in European sector and invisible in latitudinal average values. They are qualitatively consistent with observed geomagnetic-storm related changes in atmospheric circulation.

NUMERICAL MODELING OF THE EARTH'S UPPER ATMOSPHERE DURING A GEOMAGNETIC STORM

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To test various hypotheses about positive ionospheric storm development, we performed numerical simulations for the magnetic storm of 24–27 January 1974 to obtain the global pattern of the thermospheric and ionospheric effects of this magnetic storm. The global self-consistent numerical model of the thermosphere–ionosphere–magnetosphere system has been used in this investigation. The model calculates thermospheric, ionospheric and magnetospheric plasma sheet parameters as well as electric fields both of the magnetospheric and thermospheric dynamo origin. The results of the numerical simulation of the neutral composition changes agree in general with observations of the AE-C satellite and with the MSISE90 model. Although the ratio [N2]/[O] in storm maximum increases more than by factor 6 in comparison with the quiet level at high latitudes, at low latitudes it does not decrease (at fixed altitudes) below the quiet level. Meanwhile, the ionospheric storm is positive at low latitudes. Thus we can conclude that the positive phase of the ionospheric storm is created by thermospheric winds which cause an upwelling of the ionospheric F2-region plasma at mid-latitudes along the geomagnetic field lines to the heights where the ion loss rate is lower and at low latitudes this enhanced plasma is moved equatorwards by the oppositely directed thermospheric winds blowing from the northern and southern high latitudes.

COMPARISON OF MODELS AND DATA AT MILLSTONE HILL DURING THE JUNE 5-11, 1991, STORM

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We compare measurements of the ionospheric F region at Millstone Hill during the magnetic storm of June 5-11, 1991 with results from the IZMIRAN and FLIP time-dependent mathematical models of the Earth's ionosphere and plasmasphere, and the Millstone Hill semi-empirical (MH) model of the ionosphere. New rate coefficients from recent laboratory measurements of the $O^+ + N_2$ and $O^+ + O_2$ loss rates are included in the IZMIRAN and MH models. The laboratory measurements show that vibrationally excited $N_2(v)$ and $O_2(v)$ are both important at high temperatures such as found in the thermosphere during disturbed conditions at summer solar maximum. All 3 models reproduce major features of the data but none of them reproduce the observed day to day variability without modifying the MSIS neutral atmosphere. The increase in the $O^+ + N_2$ loss rate due to $N_2(v)$ results in a factor ~ 2 reduction in the daytime F2 peak electron density. On some days inclusion of $N_2(v)$ improves the agreement between the models and the data, and on other days it worsens it. We show for the first time that the increase in the $O^+ + O_2$ loss rate due to $O_2(v)$ leads to the decrease of the calculated daytime NmF2 up to a factor of 1.4.

THE ROLE OF VIBRATIONALLY EXCITED OXYGEN AND NITROGEN IN THE IONOSPHERE DURING THE UNDISTURBED AND GEOMAGNETIC STORM PERIOD OF 6-12 APRIL 1990

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The comparison the observed behavior of the F region ionosphere over Millstone Hill during the geomagnetically quiet and storm period on April 6-12, 1990 with numerical model calculations from the IZMIRAN time-dependent mathematical model of the Earth's ionosphere and plasmasphere is presented. We use the new loss rate of $O^+(^4S)$ ions as a result of the new measurements of the rate coefficients for the reactions of $O^+(^4S)$ with N_2 and O_2 (Hierl *et al., J. Chem. Phys.* **106**, 3540-3544, 1997). It was found that the non-Boltzmann distribution of $O_2(v)$ and the difference between ion and neutral temperatures can lead to the increase of the calculated NmF2 only up to 5 %. The IZMIRAN model reproduces major features of the data. The inclusion of vibrationally excited $N_2(v)$ and $O_2(v)$ in the calculations improves the agreement between the calculated NmF2 and the data on April 6,9,10. NmF2 are reproduced by the IZMIRAN model without $N_2(v)$ and $O_2(v)$ on April 8 an 11 better than those with $N_2(v)$ and $O_2(v)$. The increase in the $O^+ + N_2$ rate factor due to $N_2(v)$ produces the 5-41 % decrease in the calculated daytime NmF2. The increase in the $O^+ + O_2$ loss rate due to $O_2(v)$ produces 8-33 % reductions in NmF2. To reproduce the anomalous electron density event on April 10 with hmF2<200 km the MSIS-86 atomic oxygen density was decreased by a factor of 1.8.

RECURRENT GEOMAGNETIC ACTIVITY AND THE WARMING IN ST.PETERSBURG

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Sunspot, geomagnetic activity and the air surface temperature variations recorded in St.Petersburg since 1775 have been analyzed. A local cooling during the Dalton minimum was observed. A trend was derived from the data set, which shows a warming tendency beginning the 50s of 19th century. Temperature variation analysis shows also that the main warming is mainly due to a warming in winter when the solar-wind effect is more obvious in the Northern Hemisphere. The highest level of geomagnetic activity resulting from disturbed solar wind and interplanetary magnetic field conditions was associated with the warming in winter. The warming tendency was accompanied by increasing rate in solar wind streams just occurred near the Earth's orbit. Space weather conditions that cause extremely low temperature in winter were analyzed and discussed. A cold winter scenario in St.Petersburg in late of 1997–1998 was predicted.

IONOSPHERIC STORMS: OUTSTANDING PROBLEMS

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Seventy years after their discovery, ionospheric storms remain a most fascinating and challenging topic of upper atmospheric physics since so many aspects of this striking phenomenon are still incompletely documented and understood. One point which has to be clarified, for example, is the significance of electric fields and traveling atmospheric disturbances in explaining short-duration ionospheric storm effects at middle latitudes. Another problem area is the importance of vibrationally-excited molecular nitrogen in causing negative ionospheric storm effects. Also, with regards to modeling ionospheric storm effects, why do present-day general circulation models overestimate the increase in the O/N_2 density ratio and the attendant positive ionospheric storm effects and, at the same time, underestimate the decrease in the O/N_2 density ratio and the attendant negative ionospheric storm effects? Here we review some of the more recent publications relevant to these problem areas.

CHANGES OF SCHUMANN - RESONANCE PARAMETERS DURING HIGH ENERGY SOLAR PARTICLE EVENTS

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Schumann resonances (SR) are electromagnetic waves propagating in the earth - ionosphere wave guide with wavelengths being an integer multiple of the earth's circumference. Their amplitude depends mainly on the global thunderstorm activity, their exact frequency on parameters of the wave guide. High energy (MeV) solar electrons and protons cause additional ionization at the lower border of the ionosphere and in the mesosphere and even in the stratosphere, modifying the electric properties of the wave guide. Changes in the SR frequency have been studied systematically during events of solar energetic electron (SEE) and solar energetic proton (SEP) precipitation. We used mainly data from the station Arrival Heights in Antarctica, because these data are least affected by natural and anthropogenic electromagnetic interference. Although the frequency changes are only of the order of 1/10 Hz they can be clearly identified. The results are presented and explained in terms of the current SR theories, and their implications for the global electrodynamics is discussed.

THE SOLAR PROTON EVENTS AS AN ESSENTIAL FACTOR IN THE SOLAR - TERRESTRIAL PHYSICS

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The current level of knowledge of the magnetospheric, ionospheric and atmospheric effects produced during the solar proton events (SPE) is reviewed. The SPE signature in the ionosphere is so called polar cap absorption events (PCA) which produced damaging effects on the radiocommunication, navigation and surveliance systems. The global geomagnetic storms which often are the components of the SPE can produce severe damaging effects on the different technological systems. Besides that the SPE's produce significant effects in the polar mesosphere and stratosphere especially in the ozone layer. Experimental evidences of these effects as well as of the pure ionospheric and atmospheric phenomena are presented.

CONTRIBUTION OF ENERGETIC PARTICLE PRECIPITATION TO THE SUBAURORAL 3D CURRENT SYSTEM AND POLARISATION JET

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Energetic particle injections during magnetic storms lead to formation of asymmetric part of the ring current (RC) and of specific zones of field-aligned currents localized near the plasmapause and detached plasma regions which appear in process of the plasmasphere erosion. These field-aligned currents are due to energetic particle precipitation caused by wave-particle interactions. Together with induced currents of cold plasma, the currents of hot particles form 3D current system in the subauroral magnetosphere and ionosphere. The magnetospheric Hall conductivity plays an important role in formation of this system. leading to generation of the ionospheric northward electric field located at the ionospheric projection of RC. This electric field increases with growth of RC intensity and reaches the saturation value determined by the energy of RC ions and can explain the structure and value of the electric field observed in the polarisation jet. The 3D current system provides not only transfer of the electric charge but also mass transfer, accumulating cold plasma in two contact regions of RC with plasmasphere located in the morning side and in the eveningside bulge. Between these regions, in the night side, an impoverishment of the ionospheric plasma density takes place.

FIRST RESULTS FOR OZONE VARIATIONS DUE TO SOLAR PROTON EVENT DURING 19 OCTOBER 1989

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It is assumed that by penetration of solar cosmic rays (SCR) into the middle atmosphere the ozone is destructed. However we suppose that at certain altitudes ozone can be created as a result of chain ion reactions taking part in the stratosphere. In this investigation satellite data for ozone density in the atmosphere during SCR on 19 October 1989 were used. The values of ozone concentration (partial pressure) were taken from profiles of the following heights: 25.5 km, 24.5 km, 23.5 km, 19.5 km, 18.5 km and 11.5 km. The orbits of the satellites passed latitudes from 30° to 90° N and longitudes from 20° to 40° E. Data for the high energy protons were taken from Solar Geophysical Data - Boulder, Colorado. Cosmic ray measurements obtained from the neutral monitor in Kiel, Germany were utilized also. The influence of solar protons from seven energetic intrervals from 4.2 MeV till 850 MeV were studied. As a result of cross correlation analysis direct cause-effect relationships between ozone creation and SCR at heights 18.5-19.5 km have been obtained. These heights are situated near to the Pfotzer maximum due to the galactic cosmic rays.

IONOSPHERIC RESPONSE TO GEOMAGNETIC STORM DURING 10-11 JANUARY 1997 DUE TO CORONAL MASS EJECTION (CME) ON THE SUN

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Due to the satellite observations in the last years were discovered a new class of solar phenomena - Coronal Mass Ejection (CME), which has the necessary physical parameters to cause geomagnetic storms with SSC. On 6 th January 1997 with the satellite SOHO was observed such CME event. This mass reached the Earth environment on 10-11 January 1997 and caused geomagnetic storm, which was registrated from ground based stations and international STP satellites SOHO and INTERBALL-1. The latter measured compression of the magnetosphere with 7 R_E (R_E - radius of the Earth). The geomagnetic storm on 10-11 January caused significant effect on the ionosphere and middle atmosphere. In the paper are analyzed results from ionospheric observatory Sofia in the investigated period: variations of ionospheric critical frequencies and heights, minimum reflection frequency and limiting frequency of the sporadic E - layer (E_S).

ST10 Ionospheric modelling and predictions

Convener: Hanbaba, R.
Co-Convener: Zolesi, B.

Sponsorship: FRANCE TELECOM-CNET and Istituto Nazionale di Geofisica

COMPARISON BETWEEN IRI AND GPS-IGS DERIVED ELECTRON CONTENT DURING 1991-97: FIRST RESULTS

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The existence of a permanent network of GPS ground receivers. the *International GPS Service* (IGS), operating since 1991, allows to perform an exhaustive comparison of the global electron content derived from these data using tomographic models (Juan et al. 1997. *Geophys. Res. Lett.*, *24*. 393-396 and Hernández-Pajares et al. 1997, *Radio Sci.*, *32*. 1081-1090) with the International Reference Ionosphere predictions (IRI, Bilitza 1990,International Reference Ionosphere 1990, URSI/COSPAR, NSSDC/WDC-A-R&S 90-22). This work will allow the IRI upgrading for the electron content forecast. using this data set at global scale and along half solar cycle.
In this contribution we are going to present the status at this time of such comparison that involves more than 20 Gigabytes of GPS data between 1991 ($\simeq$30 stations) and presently (more than 200 stations).

IMPROVEMENTS IN TARGET RANGING BY HF RADAR USING THE EUROPEAN IONOSPHERIC MODEL PRIME

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Target ranging by HF radar can be done by correcting the group path of target echoes for the delay due to the propagation through the ionosphere. One possibility is to simulate the propagation by ray-tracing but in this case the final accuracy obtained in target registration depends mainly on the quality of the ionospheric model used to ray-trace. In our study, we used the PRIME ionospheric model to perform ray-tracing on a 950 km path, between Toulon and Lannion, in France, for which oblique soundings data from the SCIPION sounder are available in december 1991. The ray-tracings were performed by using the vertical profiles of electron density at five points along the path. The profiles were obtained by the monthly median and by the instantaneous mapping procedures. For comparaison purposes, we also used the vertical profiles obtained by the IRI instantaneous mapping. We present the results of this study and we discuss the accuracy in target ranging obtained for the conditions of the simulations.

POSSIBLE USE OF THE LOCAPI IONOSPHERIC PREDICTION SOFTWARE TO DIGITAL COMMUNICATIONS

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The LOCAPI ionospheric propagation software, developed by the University of Rennes 1, uses the quasi-parabolic expression of electron density profile fitted by eight quasi-parabolic layers. Its inputs are : date, frequency, transmitting and receiving locations, and solar index. An original fast and accurate algorithm determines the output parameters : MUF, occultation LUF, elevation angles, group delays, pathloss for an important range of possible propagation O and X modes. The application of this software to adaptive digital communications requires a vectorial representation of the propagation channel, a Doppler frequency shift and a noise random models, which are added to the deterministic parameters calculated by LOCAPI. The channel representation can be written as :

$$\vec{h}(\tau,t)=\sum_{k=1}^{N} a_k.[I_k].\vec{V}_k.\delta\left(\tau-\tau_{g_k}\right).e^{2\pi j\left(f_0+f_{dk}\right)\left(t-\tau_{pk}\right)}$$

where N is the number of paths, $[I_k].\vec{V}_k$, the polarization term, τ_{gk} and τ_{pk}, the group and phase delays, f_0 and f_{dk}, the transmitted and Doppler frequencies. This formalism can be used to improve the design of digital receivers, even better if the polarization and antennas effects are taken into account.

NOSTRADAMUS SKYWAVE RADAR : A 360 IONOSPHERIC SOUNDER

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The ONERA is conducting, in collaboration with THOMSON-CSF AIRSYS, the realization of the NOSTRADAMUS french skywave radar. This project, sponsored by the SPAé from the DGA (Ministry Of Defence), is based on a new concept of Over-The-Horizon radar. Definition studies with the LETTI, have led the ONERA to built a monostatic surface array radar. Such a structure allows a 360 degrees coverage and the focalization in elevation. The main mission of the radar is to detect and to localize targets over the horizon. But the system is also used for the soundings of the ionosphere to manage the radar operating frequencies. So, NOSTRADAMUS is used like a measurement tool to characterize the ionosphere and establish propagation modelling. New sounding techniques, using the elevation information and the 360 degrees scanning, have been developped for the frequency management.

Latitudinal dependence of Total Electron Content evaluated by GPS and NNSS observations at middle latitudes.

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The analysis to evaluate vertical TEC from GPS provides continuous estimates of its latitudinal slope. NNSS observations provide much more reliable values of the latitudinal dependence, but sparse in space and time; this implies difficulties in TEC modelling. The availability of many years of contemporaneous GPS and NNSS measurements gives the chance to compare directly the two sets of latitudinal dependences. Statistics of this comparison will be presented, aiming specifically to evaluate the accuracy of the GPS estimates.

THE EVALUATION ERRORS OF IONOSPHERIC PLASMA MOVEMENTS VELOCITY FROM THE VERTICAL HF DOPPLER DIAGNOSTICS

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The measurements of Doppler versus frequency dependence $\Omega(f)$ from the vertical ionospheric sounding allow a calculation of plasma movements velocity v height profiles. The calculation of v is based on the inversion of Volterra first kind integral equation. This yields in the linear dependence law of velocity from derivative

$d\Omega/df$: $v(f_p)=\int_{f_0}^{f_p} K(f_p,f)(d\Omega/df)df$, where f_p is a plasma frequency. f_0 a plasma frequency at the base of a layer, $K(f_p,f)$ a certain kernel. A velocity dispersion $\sigma^2(v)$ can be written: $\sigma^2(v)=\int_{f_0}^{f_p}\int_{f_0}^{f_p} K(f_p,f_1)K(f_p,f_2)\frac{\partial B(f_1,f_2)}{\partial f_1 \partial f_2}df_1 df_2$, where B = autocorrelation function of Doppler shift measurement errors. Results of the F – layer sounding with ordinary component $\sigma^2(v)$ study are reported. It is concluded that v diagnostics errors are of maximum value at magnetic the equator and of minimum at the poles. The ratio of these values is two. The Doppler shift measurement errors of 0.01 Hz lead to the velocity evaluation errors of several meters per second.

THE DETERMINATION OF ATTENUATION OF HF RADIO WAVES CAUSED BY THE RANDOM ELECTRON DENSITY IRREGULARITIES FROM VERTICAL SOUNDING

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A coherent component attenuation caused by scattering on the random irregularities of electron density can be evaluated from the relation $\beta^2 = I_0/I_s$ of the coherent I_0 component to the scattered I_s one. The dependence of attenuation from frequency is used to determinate the irregularities spectrum. A common way to estimate the value of β^2 is to study the amplitude distribution law of a vertically reflected from ionosphere signal. At present there are two amplitude distribution models leading to a significant difference in β^2 values. The first giving values of $\beta^2 > 1$ implies that scattering is taking place near the reflection level. The second implies scattering alone the whole propagation path and gives the values of $\beta^2 > 1$. A new approach that does not require the knowledge of the amplitude distribution law is proposed. It is based on quadrature signal components measurements. The approach allows evaluating not only β^2 but also the Doppler frequency shift and the polarization ellipse of signal characteristics. The statistical modeling shows that the greater β^2 is the smaller the errors are.

THE EMPERICAL MODEL OF EFFECTIVE ELECTRON COLLISION FREQUENCY FOR MIDLATITUDE IONOSPHERE

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A midlatitude ionosphere Empirical Model of the Effective Electron Collision Frequency (EMEECF) is proposed. It is based on the multifrequency vertical incidence ordinary and extraordinary waves ionospheric absorption observations near Rostov on Don, Russia (47^0 13′ *N*, 39^0 14′ *E*). The EMEECF describes the seasonal daytime variations in height range of 100 to 200 km, two levels of solar activity. . 104 measurement sessions in 1973 and 392 in 1988 were used.
The observed effective electron collision frequency values from the E - layer coincide with the gas kinetics predictions, while those from the F - layer exceed the later. The seasonal dependence changes the behavior and the discrepancies become greater with the solar activity growth.
The electron concentration irregularities caused scattering and an anomalous o – component absorption account for an additional noncollision radio waves attenuation leading to the theoretical and experimental results discrepancy. Observed o – component effective electron collision frequency values are 2 times greater than x – component ones. The maximum ratio of values obtained with experiment to gas kinetics values is 20. The model is useful in planning vertical sounding of the ionosphere experiments.

COMPARISONS OF PRARE TEC WITH TOPEX MEASUREMENTS AND WITH IONOSPHERIC MODELS

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The German microwave satellite tracking system PRARE (Precise Range And Range Rate Equipment) has been operating onboard ERS-2 since May 1995 with the routine product generation starting on January 1st, 1996. PRARE provides very precise range and range-rate measurements between the space segment and a globally distributed network of ground station transponders. The measurements are used for orbit determination, point positioning, Earth rotation and gravity field parameter estimation. In addition, the total electron content (TEC) can be derived from the simultaneous transmitted PRARE X- and S-band signals.
Two different methods to derive TEC using PRARE measurements as well as strategies to determine ground station dependent biases will be described. Finally, the PRARE derived TEC data are compared with IRI95, with global ionospheric maps derived from GPS carrier phase data, and with TOPEX dual-frequency altimeter derived TEC data.

NON-MOMOTONE N(h)-PROFILES RECONSTRUCTION FROM VERYICAL SOUNDING IONOGRAMS BY THE METHOD OF REGULARIZATION

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The calculation of non-monotone height dependencies of electron density, N(h)-profiles, from the vertical sounding ionograms is an inverse ill-posed problem which needs a special algorithms of regularization for obtaining of solution. In present paper one of the possible methods of regularization is considered.
Valley is described by the three parameters. Both traces of ionogram are used. The problem have been solved in two stages. At the first stage N(h)-profile is obtained by least-squares method (LSM). This solution is used at the second stage for search of regularization parameter and for determination of measurement errors of virtual heights.
The comparison of regularized solutions with LSM-estimates shows that regularized estimates are more stable to errors of experiment and they have a range of independence which is smaller than for LSM-solution.

A 3D RAY TRACING PROCEDURE TO STUDY IONOSPHERIC TILTS

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Tilts associated with ionospheric horizontal gradients are one of the causes of bearing errors in HF links. Since tilts were first observed, several geometrical models of link have been proposed. Croft and Fenwick put forward a geometrical method that supposed a spherical earth and an ionosphere assimilated with a plane mirror. More recently, Bennett and Dyson have defined an ionospheric MQP model (Multi-Quasi Parabolic) spherically stratified and non-concentric with the earth.
A three dimensional ray tracing procedure using geometrical optics is proposed. This model is based on the spatially variable parameters of the ionospheric layers obtained from forecast procedures, associated with a MQP profile. A simplified approach using predicted layers, was made previously for specular reflection. To improve the accuracy of the method, it is necessary to trace the rays, taking into account the refractive index and the gradient at each curvilinear abscissa element along the ray path. Simulations results have been obtained in the case of one hop propagation, from short to long range links as a function of time and season. A good agreement is observed with experimental data for radio links above western Europe.

THE IONOSPHERIC HOLES - MODELING AND DIAGNOSTICS

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The influence holes in ionosphere on conditions of HF radio wave propagation in approximation of geometrical optics is studied theoretically. The results of modeling of HF radio wave propagation on routes crossing hole in ionosphere are submitted. The radiotomography and modeling of ionospheric sections was used. It is shown, that trajectory characteristics of waves in coordinates hight-latitude depend on: geometrical sizes hole, direction, point, angle and frequencies of sounding. The characteristic modes of propagation are allocated - hop, captured by channel E-F, captured by hole, trapeziform, passing through hole. The heaviest interest presents the family of captured by hole trajectories. On estimations the time of delay for different conditions makes 7 - 23 ms. That fact, that holes in top ionosphere are long-living by large-scale formations, indicates on that disregard of effects of propagation of radio wave, connected with holes, will result in distortion or misunderstanding data of given monitoring, control and diagnostics of condition of ionized component of top atmosphere of Earth. That is important for diagnostics of ionosphere because in world practice the method of radiosounding of ionosphere in range HF radio wave for monitoring and control of ionosphere is adopted.

THE DAY-TO-DAY VARIATIONS IN THE IONOSPHERE

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Variations of the F2-region critical frequencies foF2 have been studied using the ionosonde data measured at Kazakstan location (Alma-Ata, 43.25o N) during the period November 1, 1985 - February 28, 1989. It has been shown the earth¶s ionosphere experiences regular variations with quasi periods of to 27(T1), 13-15(T2), 8-9(T3) days. These quasi periods take part in forming an ionospheric background level and must be taken into account to interpret disturbed ionosphere correctly. There is some spectra common for the variations of the F2-layer critical frequencies, intensity of galaxy cosmic rays, atmospheric pressure on the height h = 3340 m, intensity of solar activity and ionospheric total electron content. It has been showed co-ordination of fo F2 with F10.7 and its submission to it, at least , within T1, T2 and T3.

NIGHTTIME IONOSPHERIC ELECTRON CONTENT AND ITS VARIATIONS

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This paper reports results of the study of nighttime TEC (total electron content NF) variations based on the geostationary satellite ETS-II data provided by the receiving station §Orbitaµ (Institute of Ionosphere, Almaty, Kazakstan) between September 1985 and December 1986. Stages of the work: (1) the study of the nighttime day by day NF variations; (2) The study of the ANI (an anomalous nighttime increase in NF) statistical characteristics; (3) the analysis of the ANI structure. Critical frequencies of the ionospheric F2-layer shown in the vertical sounding ionograms have been used throughout the work (ionosonde, Almaty, j = 43.25o N, l = 76.92o E).

A REGIONAL MODEL OF THE F-REGION DAY-TO-DAY VARIABILITY

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A major limitation of existing models is that they are based on monthly median conditions and include no specification of day-to-day variability. As a consequence of this, the Maximum Usable Frequency provided by number of prevailing procedures for HF performance prediction is unsuitable for some applications because it would be quantify the performance of a radio service only 50 percent of the time. The objective of this paper is to propose derived statistically expressions to be used together with the models for median values of the ionospheric characteristics developed under the COST 251 (Improved Quality of Service in Ionospheric Telecommunications Systems and operation) project.

TEC AND TOPSIDE SHAPE OF ELECTRON DENSITY PROFILE IN EUROSTANDARD AND INTERNATIONAL STANDARD MODELS OF IONOSPHERE

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Model of the height h0.5 where the topside density has decreased to half the F2-peak density 0.5 NmF2 differs essentially in the European PRIME-DGR model, International Reference Ionosphere (IRI) and Standard Model of Ionosphere (SMI). PRIME-DGR topside shape of profile is adjusted to TEC model in Europe thus yielding h0.5 too high (up to 900 km at sunrise for high solar activity). h0.5 in the SMI is adjusted to IK-19 topside profile shape resulting in the most thin topside profile semi-thickness. IRI profile yields moderate h0.5 values. TEC predictions by the said 3 models are compared with measured TEC in Europe and America. Additional constraints on the F2 layer peak parameters and measured TEC should be applied in modelling the topside profile shape.

VIEWING IONOSPHERIC IRREGULARITIES WITH 360 DEGREES AZIMUTHAL SCANNING USING OTH RADAR NOSTRADAMUS

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Ionospheric irregularities has been studied with HF and VHF radar systems. As irregularities are highly aspect sensitive, the experimental geometry is well defined: equatorial radars must be pointed in the east-west plane while auroral radars can only sound northward. This is because their transmitted frequency are above the plasma frequency and waves are straight propagated. Using OTH radar with lower frequency allows ionospheric refraction and then, aspect angle conditions can be reached in all azimuths at midlatitude. The main problem is the difficulty to localize echoes and to separate them from ground clutter without good ionospheric ray tracing predictions. During June '97, experiments had been done using NOSTRADAMUS facilities to scan 360 degrees. Results are compared with 3D ray-tracing simulations.

AN ALGORITHM TO CALCULATE DISTURBED PERIODS FOR foF2

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An algorithm to calculate disturbed periods for foF2 and NmF2 as proposed by Kouris et al. (Adv. Space Res., in edition) is described. The obtained results using the proposed algorithm are then compared with those resulting from geophysical definitions of quiet ionospheric conditions. The comparisons lead to some very interesting conclusions about ionospheric variability and its predictability.

MODELLING OF THE E-LAYER PEAK HEIGHT AT MID-LATITUDES

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An empirical model of the E-layer peak height have been worked out using a homogeneous set of precise data of the Kharkov incoherent scatter radar located at ~50°N. A special technique was developed to minimize systematic errors of radar measurements. Only radar measurements for magnetically quiet condition with Kp-indices less than 3 have been used. These data comprise the period from 1978 to 1990. This model describes diurnal, seasonal and solar cycle variations of hmE; it could be expanded to other mid latitudes down to ~40°N. The proposed model is compared with other existing models of the E-layer peak height based on rocket and radar data. The authors feel the proposed model yields higher accuracy, in particular around noon. If approved it can be incorporated into the IRI model.

THEORETICAL MODELING OF THE REAL SPATIAL-TEMPORAL VARIATIONS OF THE MID-LATITUDE IONOSPHERE

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Despite existence of many different ionospheric models (empirical, theoretical, hybrid, etc.), the problem for describing the real distribution of the main ionospheric parameters not only for median, but also for very quiet, as well as for disturbed geophysical conditions, is far from decision.
The theoretical model (TM) proposed here can be used for describing the median distribution of foF2 and hmF2, when MSIS and HWM'90 models are used to calculate the input parameters (neutral composition, temperature and wind). However, combined with an additional procedure that allows correction of the input parameters by using Re-measurements of foF2 and hmF2 data, in a meridional chin of stations, this model describes quite well the spatial distribution of these parameters accordingly to the real state of the ionosphere.
As a median model TM has been tested over great range of solar activity, seasons, spatial areas, etc., and compared with CCIR, URSI and PRIME empirical models. Calculation of the errors' distribution gives the similar error variance for all the models, but the different position of the areas with the largest and the smallest errors.
As a re-time model TM has been tested only for a few "disturbed" and "very quiet" periods, however the results received are very hopeful.

MONTHLY MEDIAN IONOSPHERIC FREQUENCIES PREDICTION WITH NEURAL NETWORKS

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An idea has been tested with the aim of establishing a new long term prediction procedure to support ionospheric radio wave propagation at frequencies above 2 MHz.: use a neural network to model and predict the monthly median ionospheric frequencies. The neural networks have been trained with the foF2 measured data from the mid-latitude European ionospheric stations in four separate cases: (i) a simple model of the classical multi-layer perceptron (MLP) with 3 inputs: hour, month and solar activity index R12 and one output: the foF2 from Poitiers ionospheric station (46 N, 00 E); (ii) a modular neural network with the same inputs and output; (iii) a neural network with the embedding dimension and the horizon delay, using the last foF2 observations from Poitiers introduced as a time series; (iv) a neural network with latitude and longitude as new additional inputs. The results are compared with those of the classical PRIME and ITU-R models.

SPECIFICATIONS OF THE F-REGION VARIATIONS FOR QUIET AND DISTURBED CONDITIONS

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Quiet ionosphere models are based on median values of the ionospheric characteristics. Limitations arise when individual days conditions are required to be specified because specification of disturbed conditions are needed. Ionospheric conditions are based on available geomagnetic conditions but ionospheric and geomagnetic phenomena can process independently of each other. Therefore, an ionospheric definition of disturbed conditions based on the departures of foF2 from its median value as it is proposed by Kouris et al. (Adv. Space Res. in edition) is used here to estimate: 1) the mean percentage of disturbed days in each month in the European area for three reference solar epochs, 2) the percentage of disturbed hours in each month, 3) limits (positive and negative) at relative departures of foF2 from the corresponding median values for the three reference solar epochs for quiet and disturbed conditions along the year.

MAGNETIC FIELD ALIGNED MODELLING FOR THE UPPER F REGION AND FOR THE PLASMASPHERE

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Existing empirical models, e.g., the IRI and the PRIME model. have shortcomings for the uppermost F region and usually have no realistic formulation for the plasmasphere. These shortcomings can be overcome by replacing purely height oriented modelling by magnetic field aligned approaches.
A magnetic field approximation is presented which uses dipole field lines with apexes above the dip equator. Modelling along these field lines can be based on diffusive equilibrium. For a single ion plasma (e.g., an H^+ plasma) the integrations wich are necessary to model along the field lines in a realistic way can be carried out by means of series expansions. For a multiple ion plasma and in case of arbitrary dependence of electron and ion temperatures on the coordinates one has to apply numerical integration.
The principles of joining a field aligned model to a height oriented one are discussed including a method to cross the dip equator in a consistent way.
A practical example is presented with a plasmasphere model added to the global model NeUoG which was developed at the University of Graz. The future development aims at replacing all of the topside F region of the model by a magnetic field aligned approach.

SHORT-TERM PREDICTION OF IONOSPHERIC PARAMETERS BASED ON THE AUTOCORRELATION ANALYSIS

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An autocorrelation method was recently developed for temporal interpolation and short-term prediction of ionospheric characteristics. This method is used to perform 24 hours prediction of foF2 and M(3000)F2 measured at stations Uppsala, Slough, Poitier and Sofia during the last three solar cycles. For each prediction, the method determines an autocorrelation function over the last 25 days and assigns the respective weighting coefficients to the hourly values in the last 4 days. These weighted hourly values are then used to calculate the respective hourly values in the prediction period. The prediction procedure is performed for each single prediction within the whole years from 1960 to 1996. Standard deviation, as well as the probability distribution around the respective measured values are calculated for each station during the whole years considered. Results are discussed in terms of their latitudinal and seasonal (monthly averaged over the whole period) dependence. The met! hod is applied to 2- and 3-days predictions and the corresponding errors are discussed.

MODELLING OF THE MAIN TROUGH OF THE F REGION FOR COST 251

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For the equinox and winter seasons the main trough is a stable feature of the F region of the ionosphere. Since its latitudinal scale is small and since its location depends strongly on magnetic activity the trough is smoothed out in large scale monthly median models as well as in monthly median data. The trough location is well known in dependence of geographic coordinates, time and magnetic activity. Furthermore, we have now some good impression on the ionization values in the trough and can make at least fair guesses with respect to the shape of the equatorward shoulder of the trough.
We present maps for the trough in foF2 and in electron content to be superposed on large scale maps of these quantities. The trough maps need an additional input parameter for the level of magnetic activity. The trough maps reach the minimum of the trough but do not reach beyond: polewards of the minimum the variability of electron density and electron content is too strong to allow to construct useful averages.
For height profiles of electron density in the trough region we present some guidelines only.

MAPPING MONTHLY QUARTILES OF IONOSPHERIC ELECTRON CONTENT AND OF FOF2

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Monhtly quantiles of ionization parameters are important information for system planning and to assess one aspect of ionospheric variability. For ionosonde parameters the data base is probably large enough to allow mapping of deciles. For electron content the situation is not so good: at least for Europe the data base only allows to construct maps for the upper and and the lower monthly quartiles.
We present mapping procedures and maps for monthly quartiles of electron content and of foF2 based on experiences with mapping procedures for monthly medians. It turned out that for the lower quartiles it is necessary to modify procedures and to use more coefficients for the quartile maps than for the median maps. The experience gained is used to formulate mapping recommendations for the COST 251 area.
We also discuss possibilities to gain decile information for electron content from foF2. For a few selected months and locations deciles can be gained from the Faraday effect on the signals of geostationary satellites. These selected cases are used to check on procedures to use foF2 experience to construct electron content deciles.

Doris based ionospheric correction

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To compute the ionospheric correction to be applied to the single-frequency POSEIDON altimeter flying onboard T/P, we have developed a model using Doris Doppler data. The system includes a network of about 50 transmitting beacons spread all over the world, receivers flying onboard satellites and a control and processing system on ground. Each bacon transmits a signal on 2 frequencies (2 GHz and 400 MHz). The onboard receiver measures the Doppler count over a period of about 10 seconds. Assuming that Doppler measurements at both frequencies are equal except for the ionospheric effect, one can deduce the ionospheric correction to be applied to the 2 GHz.. We have about 7000 measurements each day, that are split into 2 different data sets to take into account the local time effect, and are used to estimate the TEC at every point of a regular grid.
This DORIS correction is computed operationally since the beginning of the T/P mission in 1992. We have conducted a global analysis of its quality using the Topex dual frequency information. This model will be used for the Jason and Envisat satellites. To estimate more precisely the TEC spectrum, we will ingest GPS information in the future. This will allow a very precise determination of the TEC, which will be useful to calibrate the dual-frequency correction, and to provide to the users an accurate estimate of the TEC where the dual-frequency correction is not

THE ION COMPOSITION MEASUREMENTS AND MODELLING AT ALTITUDES FROM 140 TO 350 KM USING EISCAT MEASUREMENTS

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This work aims at processing the data of CP1 program of EISCAT ionospheric radar from 1987 to 1994 using the 'global fit' method which allows to solve the 'temperature-composition' ambiguity problem in the lower F region. The data analysis program was developed in CEPHAG in 1995-96 by B. Cabrit and W. Kofman. To improve this program, we first introduced another analytical function to model the ion composition profile. Secondly, we chose the best method to select the initial conditions for the 'full profile' procedure. A statistical analysis of the results was done to obtain the averages of various parameters : electron concentration and temperature, ion temperature, composition and bulk velocity. The aim is to show the obtained models of parameter behaviour defining the ion composition profiles : z50 (transition altitude between atomic and molecular ions) and Dz (width of the profile), for various seasons and for high and low solar activities. To explain the principal features of parameters z50 and Dz, we performed a simple simulation of the processes leading to composition changes, supposing the state of equilibrium at each altitude and neglecting the terms of transport in the continuity equation. This procedure gave the same diurnal behaviour of the composition parameters as the one observed for winter and summer. But due to some simplifications of the problem, these explanations cannot be absolutely sure. In this paper, we discuss the results and compare them with the modelling.

TOPSIDE ELECTRON DENSITY PROFILES MODELING ON THE BASIS OF VERTICAL TOPSIDE SOUNDING DATA

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Topside ionosphere modelling always encountered with difficulties connected with experimental data collection. The only means for ground-based sounding of the topside ionosphere are incoherent scatter radars that are situated at several points (5 or 6 regularly working radars). They do not fulfill the necessary geophysical coverage if one wants to take into account the ionosphere variability and diversity of ionosphere behavior in different characteristic regions (polar, auroral, middle latitude, low latitude and equatorial). From the other side, the satellite data, namely topside sounding, having good global coverage are limited by local time and solar cycle phases coverage. Nevertheless, they give possibility to estimate the main characteristic parameters of the topside ionosphere behavior in different latitudinal and longitudinal regions. The main characteristics of the topside ionosphere profiles were revealed for different seasons, different levels of solar and geomagnetic activity basing on the dataset from Intercosmos-19 and Cosmos 1809 satellites. More than 3000 topside profiles were processed and parameterized. The simplified empirical formula was proposed for the topside profile presentation and values of the introduced parameter B3 were obtained for different solar-geomagnetic and geophysical conditions. The obtained values of the B3 parameter could be used for the purposes of ionospheric modelling.

IONOSPHERIC INDEX MF2 FOR MONTHLY MEDIAN foF2 AND M(3000)F2 MODELING AND LONG-TERM PREDICTION OVER EUROPEAN AREA

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A new ionospheric index MF2 for monthly median foF2 and M(3000)F2 modeling and long-term prediction has been proposed in the framework of European COST-251 Project. A comparison with other solar direct and ionospheric indexes used in practice has shown the advantage of MF2 index in retrospective mode. Distinct from direct solar indexes (R12, F10.7) such effects as •saturation• at high solar activity and •hysteresis• foF2 in the course of solar cycle are avoided when MF2 is used. Monthly MF2 indexes demonstrate regularity in seasonal variations during solar cycles, which can be used for MF2 long-term prediction method. Long-term (3, 6 and 12 months in advance) MF2 predictions were used to calculate foF2 using single station models for COST-251 ionosonde network. A comparison with foF2 observations and CCIR model predictions (based on the official R12 long-term forecast) has shown the advantage of the proposed approach based on the new index MF2.

SPACE CORRECTION OF GLOBAL MODELS OF ELECTRON NUMBER DENSITY IN THE IONOSPHERE BY RECEIVING AT ONE SITE SIGNALS FROM LOW-ORBIT SATELLITES

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A technique for updating global models of the electron density N is developed. It employs a part of the Doppler shift due to the rate of change of the total electron content determined at one site from measurements of signals from the radio beacons on low-orbit satellites. This technique enables corrections of the Chiu model over a region of about 1,000 km in a North-South direction. To study a possibility of predicting N in an East-West direction using the corrected model, we employ the measurements of satellite signals received at three sites spaced up to 2,000 km. For updating global N models, it is determined that separations between correction sites can be of up to about 3,000 to 4,000 km.

IMPROVING THE IRI PROFILE DEFINITION

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Reliable ionospheric models are required to support long-distance HF radio communication and control. For global operation, the International Reference Ionosphere (IRI) is one of the most widely used models. Deficiencies in the IRI model, specifically for lower latitudes, have been traced to the B0 and B1 parameters which specify the bottomside F2 layer. Improved parameter sets as function of dip-latitude, season and sunspot activity are being developed by comparison with ionogram-derived profiles. New solutions are now required to connect the improved F2 layer profiles to the underlying layers, i.e. either to the F1 layer or the E layer. This paper describes a systematic approach of connecting the F2 profile data for the mid-latitude and equator are used to establish a unified approach.

REGIONAL MODEL OF TEC FROM GPS OBSERVATIONS

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Regular GPS observations performed at IGS stations: Borowiec (52.1 N, 17.1 E), Lamkowko (53.7N, 20.7E), Józefos³aw (52.1 N, 21.0 E) and Wroc³aw (51.0 N, 17.0 E) has been used to create a model of TEC over Poland. The model describes the TEC distribution over latitudes of 45°–55° N and longitudes of 10°–30° E, for the period of minimum solar activity. As a basis for construction of this model we admitted local ionosphere models for individual stations. This model is a classical ionosphere single layer approach, in a sun-fixed system of coordinates. The local model represents TEC over station as a series in function of local time at subionospheric points.

The coefficients of model are computed simultaneously with equipment biases for 24 hour period. The coefficients and their number were optimised for individual stations. The local model represents the diurnal variations of TEC over a station. For regional model the latitudinal dependence parameter has been determined for TEC estimation at latitude spaced stations. In the regional model the seasonal variations are represented via the coefficients of the local models as a function of day number. New regional model describes the TEC for minimum solar activity only. In future the model will be updated to account for dependency on a solar activity.

A PIM-AIDED KALMAN FILTER FOR GPS TOMOGRAPHY OF THE IONOSPHERIC ELECTRON CONTENT

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We develop a PIM-based functional for stochastic tomography with a Kalman filter, which aids the regularization of the inversion problem associated with three-dimensional ionospheric stochastic tomography. We allow the GPS data select dynamically the best PIM parameters, in a 3DVAR fashion. We then demonstrate the value of this method analyzing IGS and GPS/MET GPS data from one day, and present our results in terms of a 4D model of the ionospheric electronic density. For validation, we compare our inferred tomographic TECs with TOPEX data, and compare the deduced PIM parameters (Solar activity indices $F_{10.7}$ and Sunspot Number (SSN), Magnetic activity index K_p, Orientation of the interplanetary magnetic field IMF B_y and IMF B_z) and outputs (critical frequencies) with GOES, ionosonde, and other data.

COMPARISON OF DIFFERENT INSTANTANEOUS MODELS OF N(h) PROFILES AT SINGLE LOCATION

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Three different electron concentration height profile models has been compared to those obtained from the ionograms at Warsaw station. The ionograms are obtained with the inversion technique of trace data to electron density profiles. These models use as an input the standard ionospheric characteristics. Some of the models has been constructed for monthly median purposes. To obtain the instantaneous profile the values of needed parameters has been taken from the simultaneously constructed instantaneous maps of ionospheric parameters. For instantaneous maps construction two techniques are used: Kriging technique with modifications concerning ionospheric behaviour which uses the deviations of measurements from the monthly median maps and fitting method which consists of updating median maps with the measurements. The comparison is done for COST 238 PRIME height profile model, a local model based on a modified Rush model and a model constructed on the base of time series of profiles and artificial neural network technique. The usefulness of the average representative height profile CARP constructed for the set of profiles for these models and the measurements is discussed.

RECENT RESULTS ABOUT THE OCCURRENCE OF F1 LAYER

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A review of recent results in the evaluation of the probability of occurrence of F1 layer and L condition is presented. Two probability functions are shown and the result of the test is discussed for different geomagnetic latitude and solar activities.

EMPIRICAL MODELS OF ELECTRON TEMPERATURE AND DENSITY IN THE OUTER IONOSPHERE FOR PERIOD OF SOLAR MAXIMA

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Thermal plasma parameters such as electron temperature (Te) and density (Ne) in the outer ionosphere have not been satisfactorily included in the most known ionospheric models (such as the last version of IRI model) so far.

Measurements onboard Intercosmos satellites yielded a data base of Te and Ne especially from periods of solar maxima. This data base has been used to construct empirical models of both parameters considering invariant latitude, longitude, local time and geomagnetic and solar activity. Systems of orthogonal functions are employed.

MESOSCALE STRUCTURES at EQUATORIAL F2 LATITUDES and NEW OBLIQUE HF TELECOMMUNICATIONS in the SUBSAHELIAN BUSH AREAS

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The network of 3 ionosondes in West Africa (Dakar, mag. latitude ml=5°N.; Ougadougou, ml=1.3° N.; Korhogo, ml=2.5°S.) provided quarterly ionograms during the IEEY (Nov. 1992 to Nov. 1994). It led us to discover two kinds of daytime F layer electron density gradients: i.) steep N.-S.-aligned fronts (crests, thin domes) with zonal gradient of $dN/dx = 3\ 10^4\ cm^{-3}\ m^{-1}$ over longitude widths of < 500km. These fronts occur from March to October at local times of about 10 and 14:30 LT, on quiet and moderately active days ($<a_p> < 3+$). ii) larger-scale latitudinal gradients over the whole equatorial zone -5° to +5° ml, from November to February (local "magnetic winter") during most of the daytime (09: to 20: LT).

We deduce corresponding (2.1/2)D gradient structures that can be used to develop economic telecommunications by oblique HF propagation between points distant on the ground of about 20 to 1000 km.

EFFECTS OF MAGNETIC ACTIVITY ON THE IONOSPHERIC MONTHLY MEDIAN VALUE f_oF_2

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Vertical sounding data monthly median f_oF_2 from 1977 to 1986 at 7 Chinese ionospheric observatories in middle and lower latitude region is used in this paper to study the effects of the magnetic activity on the average behavior of monthly median f_oF_2 and on the IRI prediction precision. Data is grouped in two cases, one is monthly averaged magnetic active index $Ap < 15$, another $Ap \geq 15$. Averaged diurnal variations of monthly median f_oF_2 shows that the bigger Ap is, the bigger averaged monthly median f_oF_2 value, and that the effects of the magnetic activity is more important in lower latitude region. Comparative study with the IRI indicates that total averaged IRI errors are bigger in higher magnetic activity than in lower. Maximum deviation of the averaged IRI errors from higher magnetic activity to lower is about 0.8MHz. The standard deviation of the IRI demonstrates an important latitudinal variation. In the lower latitude region south of Lanzhou to Haiou, The total standard deviation increases with the decrease of latitude. The standard deviation increases with the increase of the magnetic activity. In middle latitude from Lanzhou to Manzhouli, the standard deviation keeps stable when latitude increases, and it increases with the increase of the magnetic activity. An important conclusion of this study is that the effects of magnetic activity on the monthly median f_oF_2 are considerably important, and that ignoring the effects is a main source of IRI errors.

SHORT-TERM CRITICAL FREQUENCY VARIATIONS AND THEIR PREDICTIONS IN THE MIDLATITUDE IONOSPHERIC $F2$ REGION

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Seasonal and diurnal features of energy transfered from the auroral ionospheric $F2$ region into that at midlatitudes, as well as the impact of this energy relative to the energy of ionizing radiation on short-term critical frequency variations in δf_0F2 have been investigated. On this basis, methods of short- term prediction of midlatitude ionosphere δf_0F2 values were developed using the indices of solar and geomagnetic activities: the accuracy of predictions under arbitrary solar and geophysical conditions is estimated. The authors have been supported by Science and Technology Center in Ukraine Grant 471.

THE EFFECT OF THE ELECTRON DENSITY PROFILE VARIABILITY WITH TIME ON THE HF CHANNEL SCATTERING FUNCTION

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The use of vertical electron density profiles derived from ionospheric models or experimental ionograms to obtain the variability of the HF radio channel scattering function is described. Particular attention is given to its prediction in terms of time variations of the vertical profiles. The results obtained are discussed taking into account the relative effects of the different electron density vertical distribution.

A REGIONAL IONOSPHERIC MODEL FOR THE EXTENDED EUROPEAN AREA

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A regional ionospheric model of the standard vertical incidence ionospheric data, evolved by SIRM (Simplified Ionospheric Regional Model) , see Zolesi et al.,Radio Science ,Vol.28 N.4, July -August 1993 and Vol.31 N3 May June 1996, and applied to a more extended area taking into account the consequences of high latitude behaviour and of longitudinal effect, is reported in this paper. The model is still based on the Fourier coefficients coming from the analysis of the median monthly values of the ionospheric parameters measured in the stations of the European and near east regions, collected under the COST251 (Improved Quality of Service in Ionospheric Telecommunications Systems and operation) project.

ST11 New results on the dynamics of the Earth's magnetosphere from the Interball multi-spacecraft missions

Convener: Sauvaud, J.-A.
Co-Convener: Zelenyi, L.M.

PLASMASPHERE DYNAMICS ON THE DAYSIDE AND NIGHTSIDE OF THE MAGNETOSPHERE FOR DIFFERENT LEVELS OF GEOMAGNETIC ACTIVITY

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The wide angle plasma analysers for ion spectra measuring in the energy range 0 - 25.5 eV were installed on board both the Tail and the Auroral Probes of the INTERBALL mission. The report is mainly concerned to the data obtained in September - November, 1996 with the modulating analyser on board the Auroral Probe. Since the orbital period of the Auroral Probe was ~6 hours, it crosses the plasmapause on heliocentric distances > 2 R_E 8 times per day. During quiet geomagnetic conditions on September 4 - 9 the plasmasphere was asymmetric in the day - night direction. In the daytime the plasmapause was located on L ~ 4.6 on average, while its average night-time location was at L ~ 3.8. During magnetically disturbed period on September 21 - 25 the day - night asymmetry was not observed. The average plasmapause location was at L ~ 3.1 but sometimes this boundary was crossed at L ~ 2.6. All the time the "breathing" of the plasmasphere was observed. plasmapause changed its position in less than 12 hours by 0.5 - 0.8 L and the dayside and nightside boundaries moved practically in phase. During magnetically quiet periods in the region adjacent to the plasmapause ion fluxes with non Maxvellian velocity distribution were observed.

WAVES AND FIELDS AS TRACERS OF SOLAR WIND ENERGY INPUT TO THE MAGNETOSPHERE: INTERBALL-1 RESULTS.

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Interball-1 detected ULF wave energy densities in the shocked solar wind and outer magnetosphere up to some tenths of the solar wind kinetic energy density. We make use of characteristic wave and field signatures, both on the magnetospheric frontside and in the nearest tail, for the identification and study of magnetospheric boundaries and regions, such as MSH, mantle, cusp, LLBL. The MSH shocked flow is marked by compressional waves (fast magnetosonic, "lion roars"), wideband ELF wave bursts and Alfvénic vortexes, accompanied by accelerated particles. The latter incompressible waves tend to maximize near the magnetopause. The most interesting features are: (1) wave packets with amplitudes more than 5 mV/m and 10 nT; (2) current sheets and filamentary electrons with scales 1-500 km; (3) wideband bursts with ion cyclotron peaks; (4) low hybrid range waves correlated with electrons up to 1-2 keV mostly parallel to magnetic field. We briefly discuss the particle heating by the ULF waves.

VLF Plasma Wave Observations in the Polar Cusp onboard MAGION-4 Interball-1 Subsatellite.

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Magion -4 being the subsatellite for Interball-1 (Tail Probe) had orbit with apogee about 31RE and inclination 650. It was operating from August1995 till September 1997. During its operation time many crossings of the outer polar cusp were registered. For this presentation we have chosen two cusp crossings-on May 29th 1996 and May 1st 1997, when the registered low frequency plasma waves were particularly strong. The characteristic emissions are associated with lower - hybrid and electron cyclotron frequencies. The comparison of the plasma spectra and magnetic field measurements from Magion-4 and Interball-1 with plasma wave spectra will be given.

MAGNETOSPHERIC CONFIGURATION MODELING AS THE PART OF INTERBALL PROJECT

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The theoretical part of INTERBALL project includes inner magnetosphere processes analysis which may be the source of magnetospheric trap distortions realized like magnetospheric substorms and storms. The main results of such analysis are reviewed. Among the main results are - introduction of coordinate system based on magnetic flux tube volume isolines for high latitude processes description, - analysis of inner magnetosphere mechanism of Region 1 and dawn-dusk electric field support, - development of self-consistent theory of magnetospheric processes based on global plasma pressure stability analysis. During the analysis it became possible to show that the use of existing magnetic field models for ionosphere-magnetosphere mapping can bring to large errors due to ignoring of powerful diamagnetic current on the inner plasma sheet border. Theory selects plasma pressure distribution as the main parameter which must be analyzed as crude but rather informative characteristic of magnetospheric plasma trap. The importance of medium scale plasma turbulence research is discussed. It is shown that medium scale plasma turbulence may be one of the main factors of plasma trap magnetostatic equilibrium support. The perspectives of substorm plasma configuration researches are analyzed.

THE LARGE AMPLITUDE WAVE ON THE DAYSIDE MP

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On July 24, 1996 the entire magnetosheath (MSH) moved past the INTERBALL-1 spacecraft twice within 8 min. Such rapid inbound and outbound complete transits through the MSH suggest the propagation of the antisunward moving boundary wave with an amplitude of 5 R_E. The boundary wave reached Geotail 6 min. later than INTERBALL also moved in an antisunward and northward direction. GOES-8 records transient decrease in the magnetic field strength flanked by two increases. MP movement was couple to the ionosphere where it produced impulsive transient events and auroral brightening. Solar wind observations indicate no changes in the dynamic pressure. The authors interpret the event on this day in terms of a hot flow anomaly (HFA) produced by the interaction of a solar wind tangential discontinuity with the bow shock and penetrated to the MSH. HFAs can provide an order of magnitude decrease in the solar wind dynamic pressure giving rise to large amplitude MP motion. Several of the features associated with HFAs were identified at both INTERBALL-1 and Geotail.

MULTI-SATELLITE OBSERVATIONS OF THE SUBSTORM DYNAMICS DURING THE EVENT ON NOVEMBER, 14, 1996

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We investigate the dynamics of substorm on the example of substorm activation on November 14, 1996. The data of INTERBALL-1 and 2 satellites as well as ground observations were used in the analysis. During the event INTERBALL-1 was located in the center of the plasma sheet at X_{GSM}=-24 R_E, while INTERBALL-2 simultaneously observed substorm like auroral manifestations. Analysis of the dynamics of plasma and magnetic field indicates injections in the auroral region and plasmoid formation downstream of the INTERBALL-1. The successful orbit configuration enable INTERBALL-1 to spend a long time in the current sheet and conduct the detailed study of plasmoid properties.

STRONG STORM ON OCTOBER 22,1996: MULTISPACECRAFT STUDY.

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The unique possibility to conduct multipoint observations of strong magnetospheric storm (with peak Dst value of -110 nT) was met on October 22, 1996. Storm was caused by passage of a twostream interface region in the solar wind. During the main phase a set of substorm onsets was detected. The INTERBALL-Tail probe which has been well inside the plasmasheet detected magnetopause crossing and disappearence of plasmasheet soon after the first onset. The INTERBALL- Auroral simultaneously observed the intensive injections. We made an attempt to define the mechanism of strong shrinking of magnetospheric size and estimate energy, injected to the ring current and possible energy losses to the distant magnetotail. We discuss the possible scenario of storm triggering by LLBL processes.

PLASMASHEET RESPONSE TO MULTIPLE SUBSTORM ACTIVATIONS

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On 9 December 1995, the Interball-Tail probe passed inbound through the midnight sector of the plasmasheet (PS) encountering at $x = -10$ to $-12R_E$ a few sequences of magnetic field stretching, PS thinning, exit to the lobe and re-entry into the PS due to PS expansion/dipolarization. Each sequence was well correlated with the vortex-like equivalent substorm current structures. Pi2 and PiB magnetic pulsations and other substorm parameters observed in the conjugate area in northern Scandinavia, although most of them had very weak ground magnetic effects and were localized to latitudes of a contracted oval. Details of the PS response to multiple substorm activations are explored with observations both deep inside the PS and at its boundary. Substorm current wedge effects on the ground and in the PS are identified and a.o.th. discussed

STRUCTURE AND PROPERTIES OF ENTRY LAYER UNDER DIFFERENT ORIENTATION OF INTERPLANETARY MAGNETIC FIELD.

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INTERBALL-Tail is the only modern satellite crossing the region of "entry layer", where cusp field lines enter the magnetopause. More than 20 crossings of this region under different interplanetary media conditions give information about structure of the "entry layer" and magnetopause at the cusp throat. The very long boudary layers were observed in this region. In most cases the behaviour of ion fluxes there can be explained with reconnection model. The attempt to distiquish the cases with clear reconnection sign and ones with turbulent interaction of draping magnetosheath plasma and magnetospheric field was made. The dependence of the type of interaction on the direction of the interplanetary magnetic field was investigated. It was shown, that in many cases, the population of boundary layer in the "throat" consists of "remained" part of particles precipitated into cusp.

DISTRIBUTION FUNCTIONS OF THE THERMAL H^+, He^+ AND O^+ IONS IN DIFFERENT ZONES OF THE MAGNETOSPHERE

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HUPERBOLOID instrument on Auroral probe satellite measures H^+, He^+, O^{++} and O^+ ions in energy bandwith from 1 eV till 80 eV. Distribution functions of these ions are compared in different zones of the magnetosphere (outer plasmasphere, magnetic flux tubes above diffuse aurora, above auroral oval of discrete forms, and above the polar cap). These distribution functions also are compared with theoretical "polar wind".

ANALYSIS OF 3D ION DISTRIBUTIONS OBSERVED BY INTERBALL AP IN THE CLEFT ION FOUNTAIN

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INTERBALL AP was launched on August 29, 1996. After more than one year of operation, full MLT coverage has been obtained above subauroral, auroral and polar latitudes, at altitudes from (10.000 up to (20.000 km, intermediate between those covered by FAST and POLAR. The thermal ion mass spectrometer experiment Hyperboloid, on board Interball AP, provides full 3D ion distributions with mass discrimination (H^-, He^-, O^-, O^{++}) in the 0-80 eV range. Using combined measurements by the thermal ion (HYPERBOLOID), high-energy ion and electron (ION), and low-frequency electric field (IESP) experiments, we present results obtained both in the dayside (cleft ion fountain, magnetosheath ion injections in the cusp region) and in the nightside (low energy ion conics, identification of magnetospheric boundaries) sectors. Distributions observed at the equatorward edge of the polar cleft region reveal strong, altitude-cumulative perpendicular heating, probably associated to wave-particle interactions. Further poleward, the distributions evidence significant energy-latitude dispersion, characteristic of the cleft ion fountain. These distributions are analyzed in terms of energy and pitch-angle spread in order to deduce the properties of the acceleration region where they originated.

FAST VARIATIONS OF ION FLUX AND IMF IN THE EARTH'S FORESHOCK REGION: INTERBALL-1 AND MAGION-4 MEASUREMENTS.

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Fluctuations of the solar wind ion flux and interplanetary magnetic field at the foreshock are investigated on the basis of INTERBALL-1 measurements with time resolution from 1/16 s till 1 s. Ion flux and IMF variation levels were compared with type and dynamics of reflected ion spectra and unambiguous relations between them were found. The high positive correlation (correletion coefficient is about 0.75) of ion flux and IMF variations was observed at the foreshock region that significantly differs from one in the magnetosheath and quite solar wind. The position and motion of foreshock boundary are studied by means of INTERBALL-1 and MAGION-4 measurements and some preliminary results are discussed.

HIGH LATITUDE MAGNETOPAUSE IN THE VICINITY OF CUSP DURING STRONG NORTHWARD IMF. EVIDENCE FOR RECONNECTION.

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The stable and strong northward interplanetary magnetic field on May 29, 1996 created the unique opportunity to check the structure of high altitude cusp under such conditions. The reconnection at magnetopause region norhtward from the cusp was highly expected. The INTERBALL satellite crossed magnetopause in vicinity of the cusp at that time. The complicated ion distribution function was measured in magnetosphere beneath magnetopause. Two antiparallel magnetosheath-like ion streams were observed during rotation of magnetic field associated with magnetopause current layer. All observed features can be explained by reconnection occured tailward from the satellite. The measurements were compared with MHD simulations with good agreement in plasma parameters profile as well as the topology of reconnection.

PLASMA COMPOSITION IN THE OUTER HIGH LATITUDE MAGNETOSPHERE

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The high inclination (65°) and high apogee (203000km) of the Interball satellite make it regularly pass through the outer regions of the magnetosphere, for example the entry layer, the exterior cusp and the mantle.
The PROMICS-3 particle spectrometer has the capability to distinguish different ion species with masses up to $64a.m.u./q$, besides energy in the interval $1.5eV$ to $50keV$. detection of O^+ and He^+ ions indicates that the plasma detected is of ionospheric origin as well of solar wind origin. Some examples of data from different orbits and regions are presented and commented, showing cases where plasma of ionospheric origin is detected, or and cases when it is not. Some instrument effects are also discussed.

OBSERVATIONS OF THE AKR AT THE ENTRIES INTO THE NIGHTSIDE AURORAL REGION FROM INTERBALL-2

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Although more than a half of POLRAD observation time is covered by the AKR emissions, there is no clear evidence of crossing of their sources at altitudes ranging from 10 000 to 19 200 km. Instead, several crossings of the auroral acceleration regions can be associated with the AKR emissions originating from the sources located along the magnetic field lines well below the spacecraft. We have concentrated on sporadic AKR events, characteristic for their sudden appearances over a wide frequency range of hundreds kHz, lasting for a few minutes. The radiation appears to be propagated upwards in narrow cones of a few degrees width in longitude, from the whole altitudinal extent of the sources. They are observed mostly in the pre-midnight sector, while the spacecraft enters the auroral region. It is discussed whether it is a spatial or temporal effect. Implications for the AKR generation are proposed.

STRUCTURE OF THE FLANK MAGNETOPAUSE FOR HORIZONTAL IMF: INTERBALL OBSERVATIONS

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Magnetic reconnection of the IMF and magnetospheric field lines is one of the most probable momentum transfer processes across the magnetopause. If the By component of IMF is dominant, the reconnection can occure in the wide region at high latitude where the cusp magnetic field lines are antiparallel to draping solar wind ones. During low latitude flank magnetopause crossing INTERBALL satellite observed plasma and magnetic field behaviour showing the reconnection process occurs at high latitudes northward the spacecraft. The high energy magnetospheric ions were observed in magnetosheath region and D-shape disribution of ions of the magnetosheath origin was registrated in magnetosphere. The presense of the 90° velocity shear leads to complex 3-dimensional structure of magnetopause and transition layer in the vicinity of the reconnection site. The magnetopause in this case could not be described as rotational discontinuity and the correct deHoffman-Teller frame could not be found. The model of the flank magnetopause in the presence of reconnection was proposed to explain the observations.

LARGE SCALE DYNAMICS OF THE MAGNETOTAIL DURING SUBSTORM EXPANSION: INTERBALL, GEOTAIL, IMP-8 OBSERVATIONS

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We report substorm observations simultaneously performed with INTERBALL, IMP-8 and GEOTAIL located in the magnetotail. Auroral and near-Earth tail substorm activity are analyzed with the help of ground magnetometers and geosynchronous satellites. Using WIND data, we estimate the electromagnetic coupling and the mechanical stress between the solar wind and the magnetosphere. The substorm induced large scale magnetotail reconfiguration, tail current changes and plasma sheet dynamics are analyzed and discussed. We finally attempt to organize the set of data in order to give an account of the global response of the magnetotail to substorm expansion.

OBSERVATIONS OF ELECTRON PITCH ANGLE DISTRIBUTIONS IN THE NIGHTSIDE MAGNETOSPHERE FOR DIFFERENT PHASES OF A SUBSTORM.

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The Interball- Tail Electron instrument observations are presented.In the nightside, mid distance magnetosphere, different types of electron pitch angle distributions were detected: field aligned, loss cone and ring type, depending on particle energy, satellite location and phase of geomagnetic activity. We compare different cases of such distributions, relate them to different phases of substorms and try to give physical explanation of theirs generation and evolution.

ALMOST MONOENERGETIC IONS NEAR THE EARTH'S MAGNETOSPHERE BOUNDARIES

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More then 120 cases of energetic ion beams with energy spectrum consisting of 1-3 narrow lines were observed during a period from August 1995 to September 1997 in the Earth's magnetosheath and in the region upstream of the Earth's bow shock. It was done in a course of DOK-2 experiment onboard of Interball-1 spacecraft. The relative width at half maximum of these lines varied from 5 to 30%, therefore we use the term "Almost Monoenergetic Ions" (AMI) for these events. The fact that AMI events were not observed in numerous previous experiments can be explained by short duration of the events (~1 min) and insufficient energy resolution of spectrometers used before. Ion energy values varied for different events from 30 to 600 keV but are almost unchanged during each event. In ~50% of cases there were 2 peaks in spectra with their energies ratio of 1:2. AMI events were observed when the spacecraft was connected with the magnetopause by magnetic field lines and the energetic particle telescope was directed to the side of the connection point. Such line spectra can not be explained by models of particle acceleration or escape from the magnetosphere accepted now. We deal here possibly with some new process in near Earth's plasma or some unexpected manifestation of previously known processes. We propose a hypothesis explaining main features of AMI. It is based on the assumption of an electrostatic field burst in small region on the magnetopause.

GAPS IN THE ION SPECTRA IN THE INNER MAGNETOSPHERE

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Deep dropouts in the ion spectra were observed by mass spectrometers of the ION experiment of the INTERBALL-Auroral spacecraft. The dropouts, refered to as "ions gaps", sometimes are rather narrow in energy range. They are registered in a wide MLT band in the dayside magnetosphere at altitudes 13 000 – 20 000 km above diffuse aurora. Two types of gaps are considered: narrow energy range A – gaps (~ 10.0 – 14.0 keV) appear in the evening and morning sectors; while B – gaps (~ 0.1 – 8.0 keV) appear throughout the dayside with energy increasing towards lower latitudes. Modelling of the respective ion drift trajectories shows that A-type nearly monoenergetic gaps occur on closed drift paths not connected to the plasma sheet source, while the B-type gaps develop for a certain range of ion energies for which the residence time on a drift trajectory is higher than the ion lifetime defined by ion losses due to ion charge exchange on neutral atoms of geocorona. and also by wave – particle interactions.

SIGNATURES OF THE SOFT ELECTRON PRECIPITATION REGION AT THE POLEWARD BOUNDARY OF THE NIGHTSIDE AURORAL OVAL : INTERBALL AP OBSERVATIONS

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A narrow region of suprathermal electron precipitation (energies less than a few hundred eV) is often observed in the nightside sector, just poleward of the velocity dispersed ion precipitation region. The analysis of data from the thermal ion mass spectrometer experiment Hyperboloïd on board the INTERBALL auroral satellite (measurements of full 3D distribution functions in the 0-80 eV energy range) shows that this transition region between the open field lines in the polar cap and the plasma sheet boundary layer is also characterized by intense fluxes of upgoing thermal and suprathermal ions, mainly H+ and sometimes He+ and O+. The energy spectrum of these ions extends from a few eV up to a few hundred eV. The pitch angle distribution covers all angles between 90° and 180°. These observations made in the 15000 - 20000 km altitude range are discussed in terms of combined action of ionospheric ion heating at low altitudes due to electron precipitation and ion heating or scattering all along the field lines, together with the transport of the plasma in the convection electric field.

AKR AND ASSOCIATED EVENTS : FIRST INTERBALL 2 RESULTS ON PROPAGATION CHARACTERISTICS

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Waves observed in the 10 Hz - 2 MHz frequeny range by the INTERBALL 2 satellite inside regions of enhanced flux of particles are presented. High altitude AKR emissions are associated with VLF auroral hiss, ELF emissions well above the local proton gyrofrequency, Broad band Electrostatic Noise and electrostatic turbulence. Waveforms of one electric and three magnetic wave field components, recorded over short time intervals (~ 0.32s), are used to determine the main propagation characteristics of the waves (sense of polarization, degree of polarization, ellipticity, wave normal direction). When it exists, the Z mode L=0 low-frequency cutoff, is used to estimate the local plasma frequency. The value so obtained may be quite different from the auroral hiss high-frequency cutoff. Ellipticity values and wave normal directions, estimated under the plane wave approximation, are used to test generation and propagation mechanisms.

THE STRUCTURE OF THE CUSP–MAGNETOSHEATH INTERFACE UNDER DIFFERENT SOLAR WIND CONDITIONS

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The paper presents results of the INTERBALL–1 and MAGION–4 observations of the high–altitude cusp and magnetosheath supported by the WIND solar wind and DMSP low–altitude measurements. Statistical processing of two years of MAGION–4 measurements shows the presence of the magnetosheath like plasma well bellow the expected magnetopause position. This region is strongly turbulent but two point observations of shortly spaced INTERBALL–1 and MAGION–4 satellites allow us to distinguish its spatial structure. The entry of the plasma into the cusp region is a combination of the steady plasma flow along the reconnected magnetic field lines and the bursty injection invoked by strong turbulent processes in the cusp–magnetosheath boundary. These processes seem to be controlled by both solar wind parameters and the interplanetary magnetic field direction. The analysis of the data indicates significant portion of the plasma entering magnetosphere tailward of the cusp determined from DMSP observations.

OBSERVATION OF ELECTROMAGNETIC FIELD AND PLASMA IN THE MAGNETOSPHERE ABOVE TROMSØ HF HEATING FACILITY

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Joint experiment using the INTERBALL-2 (AURORAL PROBE) satellite and the EISCAT ionospheric heating facility were carried out in October-November 1996. In these experiment, the Tromsø HF transmitter was amplitude modulated at a frequency of 1733 Hz. Signals radiated from the heated region in the polar electrojet were detected aboard the satellite at this frequency during two out of four passes. The most prominent effects were encountered on 27.10.96 around 21.31 UT during 7 minutes, just a few minutes before the onset of a magnetic substorm. The observations include a) DC electric and magnetic fields variations, b) electromagnetic turbulence in the frequency range up to 10 Hz, c) broad band VLF emission around modulation frequency and subharmonic, d) burst of 0.1-6 keV electron and proton flux. Possible mechanisms responsible for results of the experiments are discussed, assuming that they can be triggered by the upstream particle flux and VLF emissions.

ULF WAVES OBSERVED IN THE AURORAL REGION BY THE INTERBALL AURORAL PROBE

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Electrostatic and electromagnetic waves in the ULF frequency range (0.1-10 Hz) are commonly detected in the altitude range (10.000-20.000 km) covered by the INTERBALL Auroral probe. The good sensitivity of the triaxial search-coil magnetometer and of the 3 pairs of electric sensors allows to determine without ambiguity the characteritics of the waves which are amplified in this region and/or can propagate through it. The analysis of electron and ion distributions leads to conclude that, even at the apogee (20.000 km), parallel potential drop develops. At the same time we observe Alfvenic fluctuations, which suggest that the parallel electric field is related with the AlfvÚn waves. A careful analysis of the spectrum of the ULF emissions shows that in addition to the Alfvenic electromagnetic fluctuations, electrostatic waves are sometimes detected; we present examples where these electrostatic emissions are amplified at frequencies ~FO+. The typical shape of the electron distributions observed simultaneously leads to interpreted these waves as current driven instabilities.

VARIATIONS OF THE MAGNETOSHEATH FLOW

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Present understanding of the solar wind magnetosphere interaction is based on an assumption that all changes of the solar wind dynamic pressure reach the magnetopause and that the direction of the interplanetary magnetic field controls that of magnetosheath field. We have used the period February - March 1997 when the MAGION-4 and INTERBALL-1 spent significant part of their orbits in the magnetosheath and WIND and IMP-8 were monitoring solar wind to test these ideas. The analysis of simultaneous solar wind and magnetosheath observations shows that the problem of the magnetosheath flow is more complex and suggests significant corrections of our knowledge on the magnetosheath flow. The observed long- and short-term variations of the magnetosheath ion flux cannot be explained in frame of the present models and our results indicate an importance of the interplanetary magnetic field direction in the formation of the magnetosheath flow. The role of enhancements of accelerated particle fluxes is discussed for observed phenomena.

OBSERVATIONS OF ENERGETIC PARTICLES INJECTION AT INTERBALL-TAIL PROBE DURING SUBSTORMS ON OCTOBER 22-23, NOVEMBER 14-15 AND DECEMBER 22, 1996.

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We present the observations of energetic particles, plasma and magnetic field during three big magnetic substorms in 1996. These results were obtained by using data of energetic particle spectrometers SKA-2 and DOK-2, plasma spectrometers PROMICS-3 and CORALL and magnetometer MIF-M onboard Interball-Tail Probe satellite. Main part of these periods Interball-Tail Probe was located within the plasmasheet at the distance of about 10-22 Re. One of the interesting features of these events was the appearence of charged particles with energy close to 1 MeV during the recovery phase. We can assume two mechanisms of acceleration. One is large-scale acceleration associated with dawn-dusk electric field and the other is small-scale acceleration due to local reconnection processes in the disturbed plasmasheet.

INVESTIGATION OF A POSSIBLE LONGITUTINAL VARIATION OF = RECONNECTION SIGNATURES USING INTERBALL-1 DATA

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We investigate the longitudinal dependence of reconnection signatures = observed by INTERBALL-1 magnetometers in relation with auroral = substorms.=20 The signatures are decreasing B_x, plasma sheet thinning, decreasing = or negative B_y due to Hall currents and bipolar B_z structures. The observations were made during plasma sheet encounters between = $X_{GSM} = 3D-12$ and $-24\ R_E$ and between $Y_{GSM} = 3D-11$ and $= +12\ R_E$. They appeared from minutes to tens of minutes before auroral substorm = onsets, determined by magnetograms, meridian scanning photometers and = radar observations. In all cases, INTERBALL recognized magnetic = oscillations in the Pi2-pulsation frequency range. In one case, the INTERBALL-1 and WIND spacecraft were observing similar = features at the same time but at opposite flanks of the tail.=20 The observations agree well with the theoretical prediction of a = transition to globally coherent reconnection during substorms (cf. = Büchner et al., session ST 12, this EGS meeting).

WAVE PACKETS OBSERVATIONS IN THE EARTH'S CUSP REGION, AT THE MAGNETOPAUSE AND INSIDE OF THE PLASMA SHEET BY THE MEASUREMENTS ON BOARD INTERBALL-TAIL PROBE.

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A new method of the wave analysis based on the 'scalar' and 'vector' correlative dependencies have been developed and applied to the magnetic field data from INTERBALL-1 satellite. It provides the efficient spectral analysis of vector variables and gives wave vector angular distributions and polarization states of the electromagnetic and MHD plasma waves. The ULF wave properties are studied in the three different regions of the magnetosphere: in the high-latitude cusp region, at the magnetopause, and in the plasma sheet, during the higher level of wave activity. The discrete wave packets are characteristic for the low frequency variations in all these regions. Various events differ from one another by the wave mode composition. The ion-cyclotron wave packets in correspondence to various ionospheric ion species are found in the high altitude cusp region and in the tail plasma sheet. In contrast, the spectra composed completely from packets of the linearly polarized compression mirror waves were observed nearby the high latitude magnetopause in time of the strong magnetosphere compression under the blow of the high density plasma cloud coming from the Sun on January 11, 1997.

FLANK MAGNETOPAUSE POSITION AND ITS VARIATIONS

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The position of the magnetopause (MP) is determined by the solar wind dynamic pressure and interplanetary magnetic field (IMF) direction. Statistical processing of thousands of observed magnetopause crossings led to the development of various models which well predict the size and shape the magnetopause in the subsolar region but the spread of experimental points around the mean surface is rather high on the flanks. Our analysis of the simultaneous solar wind (WIND), magnetosheath and magnetopause (INTERBALL-1 and MAGION-4) observations shows three sources of this spread. First of them are long-term variations of the magnetosheath density which do not correspond to the changes in the solar wind, the second is connected with transient enhancements or depletions of the magnetosheath density and the third can be attributed to the instability of the magnetopause itself. The IMF may control both the external (magnetosheath) and the internal (plasma sheet) boundary conditions for the flank MP processes and thus it may contribute to all three sources.

INTERBALL AND POLAR CORRELATED MEASUREMENTS OF VELOCITY DISPERSED IONS INSIDE AURORAL SURGES

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We report on the frequent occurrence of nightside ion dispersion structures measured onboard the INTERBALL-AURORAL satellite at an altitude of about 3 Re, near the boundary between the polar cap and the auroral zone. Ion energy dispersions are related to the occurence of auroral surges simultaneously measured by the UVAI camera onboard POLAR. Northward of the surge, fluxes of low energy electrons are systematically detected. More deeply into the surge, intense fluxes of keV electrons are associated with energy dispersed keV ions and with ion conics. As INTERBALL progresses southward, clear repetitive dispersion structures indicative of the bounce of injected hydrogen ions can be detected. From ion dispersions we try to infer the location of the injection region. Initial computations indicate a source distance to the satellite as close as 10 Re. We finally present electromagnetic field data showing evidence for the development of the auroral surge in association with the detection of Alfvén waves.

PROMICS-3 INVESTIGATIONS OF PLASMA ENTRY INTO THE MAGNETOSPHERE

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In this paper, results from the PROMICS-3 instrument concerning plasma entry into the magnetosphere will be reviewed. A very interesting aspect of the Interball-1 measurements is that they seem to indicate that plasma entry takes place not only in the cusp, but also through many other parts of the magnetopause. PROMICS-3 finds plasma of magnetosheath type in several places other than the cusp, both on the dayside equatorward of the cusp and on the nightside inside the magnetopause.
Interball-2 sees dispersion structures, both in the morningside and in the eveningside. Such structures have earlier been studied by Viking and have been interpreted as the low altitude signature of injections of magnetosheath plasma. We present one example from October 4, 1996, in which PROMICS-3 on Interball-1 measured a very structured magnetopause with several alternating regions of tailward and earthward flowing plasma, while PROMICS-3 on Interball-2 measured dispersion structures above the conjugate morningside auroral oval.

THE CUSP/MAGNETOSHEATH CONNECTION: MAGNETOPAUSE INDENTATION AND TURBULENT BOUNDARY EFFECTS

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We present results of the cusp/ magnetosheath interface study by Interball-1 and Magion-4. The comparative Polar data are also discussed along with modelling results. Significant MP indentation both in the X and Y directions is found. It can result in the turbulent mixing driven by the MSH flow interaction with the deformed MP. Cusp field lines, which crossed turbulent boundary layer (TBL), experience essential stochastic behavior but on average provide topological connection between the cusp and magnetosheath. This picture differs dramatically from the laminar reconnection one at the low latitudes that is characterized by the presence of rather smooth accelerated ion flows versus the detected ion heating and bursty accelerations in the TBL. In the TBL ULF waves with amplitudes more than 0.3 of the total magnetic field serve as the intermediate chain in the SW energy transformation.

STATISTICAL STUDY OF PARTICLE FLUXES IN THE MAGNETOSPHERE

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The spacecraft pair consisting of the INTERBALL 1 and MAGION-4 satellites often encountered electron fluxes of different origin. We present a statistical analysis of these encounters based on a large data set. We use the data provided by the VDP Faraday's cups during 20 months of operational period of Magion-4 satellite between August 1995 and September 1997. We construct spatial distributions of particle fluxes as the relative occurrence rates in different regions scanned by the INTERBALL orbit. The spatial distributions of electron fluxes show two principal regions of occurrence in the magnetotail: (a) near the magnetospheric boundary layers (b) near the plasma sheet. The distributions further depend on the geomagnetic activity and on the direction of the interplanetary magnetic field.

ROTATIONAL WAVES AT THE FLANK MAGNETOPAUSE

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Observations carried out in the scope of the INTERBALL project near the flank magnetopause reveal a very complex transition between the magnetosheath and the Earth's magnetosphere. Both magnetic field and plasma measurements indicate that it consists of thin layers (filaments) observed in association with the large amplitude rotational (Alfven) waves. Properties of these waves are presented and possible hypothesises on their origin are discussed by using the simultaneous measurements performed onboard the INTERBALL-TAIL spacecraft and MAGION subsatellite.

EVOLUTION OF THE ELECTRON PITCH ANGLE DISTRIBUTIONS DURING DIPOLARIZATION PHASE OF SUBSTORMS OBSERVED BY INTERBALL-TAIL.

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During the dipolarization phase of magnetospheric substorms, the same evolution of the electron pitch-angle distribution is often observed. When crossing the plasma sheet inward from the outer edge, ELECTRON experiment onboard INTERBALL-TAIL exhibits : (i) a beam-like structure aligned with the magnetic field, (ii) a butterfly-like distribution with enhanced density at intermediate pitch angles, (iii) a pancake-like distribution with enhanced fluxes in the perpendicular direction. Those structures are observed in the near tail (at about 8 Re), and are linked to the spatial displacement of the spacecraft. This evolution of pitch-angle distributions can be described using the conservation of the first two adiabatic invariants. Quite near the earth, betatron heating is a much more efficient process that Fermi acceleration but, in a realistic magnetic field model, Fermi acceleration dominantes for L-shell greater than 6-8 Re because of the shape of the magnetic field line.

SUBSTORMS AND PSEUDO-BREAKUPS AS SEEN FROM COORDINATED INTERBALL, GEOTAIL, LANL, AND GROUND-BASED OBSERVATIONS

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Brief overview of several substorm case studies made on the basis of observational campaigns of November, 1995 and November, 1996 is presented. During the intervals the Interball Tail spacecraft apogee was in the night side magnetosphere. The Interball observations have been strongly supported by the Geotail and LANL spacecraft. The considered events include various auroral activations: pseudo- breakups, substorms on contracted oval, substorm onsets at latitudes of the expanded oval, etc. The consideration allows us to make two main conclusions. The first one is that there is no principal difference between magnetospheric manifestations of pseudo-breakups and "real" substorms. The second conclusion is that auroral breakups show very clear association with the near-Earth neutral line and plasmoid signatures. We did not found any significant delay between ground- based and magnetospheric signatures of the substorm onset.

STUDY OF COMPRESSIONAL PC5 WAVES IN DAWN PLASMA SHEET BY MEANS OF INTERBALL-1

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Compressional waves of the Pc5 frequency range are studied. Magnetic field and plasma data are taken for the October 1995, when Interball-Tail was passing the dawn flank of the magnetosphere. Anti-phase variations of magnetic field and ion plasma pressures at the plasma sheet are analyzed. Method of search for morphological dissimilarities in two time series is applied. Power spectra are obtained in terms of Maximum Entropy Method and Maximum Likelihood Method, and characteristic frequencies of the wave processes are estimated. Magnetic field disturbances along and transverse to the local field line are evaluated. The vortical flows were found to be probably associated with these waves. Dependency of obtained power spectra on a number of plasma parameters and consistency with theoretical predictions are discussed.

MAGNETOSPHERE RESPONSE TO MAGNETIC CLOUDES: INTERBALL MULTI-SATELLITE OBSERVATIONS

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Several unusual features related to the interaction of magnetic clouds with Earth's magnetosphere as observed on the INTERBALL satellites during 1995-1997 are discussed. The main cause of magnetospheric disturbances is high pressure pulses on leading and trailing edges of clouds. Interactions of clouds with the magnetosphere results in its compression and deformation, large scale motions of the magnetic tail and initiations of substorms. Several important consequences of these processes were (1) observations of magnetospheric regions and boundaries much closer to the Earth than on average; (2) increases of density and temperature in outer regions of magnetosphere; (3) multiple crossings of geomagnetic tail boundaries presumably due to tail flapping, and (4) bursty fluxes of high energy ions and electrons in the auroral region and polar cap.

ON THE INTERBALL-2 ELECTRIC POTENTIAL

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The results on the S/C electric potential in respect to plasma from the INTERBALL-2 satellite (Auroral Probe) are presented and analyzed together with the data on thermal plasma. The data indicate relatively low S/C potentials till the apogee (~ 19000 km) and are shown to be consistent with the model. Possible influence of the S/C potential on the onboard thermal plasma measurements just outside the plasmapause is analysed and examples are shown using the data measured by different instruments onboard the INTERBALL-2. The INTERBALL-2 potential variations dependence on environment plasma parameters during distorbed and quiet periods is analysed.

THE PLASMA SHEET ASYMMETRY AS FUNCTION OF IMF B_Z AND B_Y: TAIL PROBE OBSERVATIONS

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In accordance with orbit evolution at period from the middle of September, 1995 to the end of February, 1996 the satellite passes the plasma sheet at regular interval of about 4 days in geomagnetic time regions of 6-0 and then 24-18 LT and at geocentric distances from 3 to 28 Earth' radii. On the basis of plasma and magnetic field observations, the positions of plasma sheet, magnetic field distribution there and their statistical dependence on the IMF B_y and B_z componets are studied and compared with previous results and models. Prelimenary results showed that the plasma sheet shifts in $+Y_{GSM}$ direction when the IMF B_y is negative and in $-Y_{GSM}$ direction when the IMF B_y is possitive. Asymmetry is studied with larger statistics and compared with previous results and models.

INTERBALL DUAL-SPACECRAFT OBSERVATIONS OF SERIE OF SUBSTORMS ON DECEMBER 22-23, 1996

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Optimal orbits of INTERBALL Tail and Auroral Probes allowed us to study the cause-and-effect relationships between the plasma processes in the geomagnetic tail and in the auroral particle acceleration region for multiple substorm events on December 22-23, 1996. This time interval was characterized by almost constant solar wind pressure ~1.2 nPa; IMF B_z component returned southward at ~11.20 UT on December 22 and was negative till ~12.00 UT next day. At ~12.00 UT on December 22 the ground stations observed beginning of the strong magnetic disturbance, and although IMF was relatively constant there were also two substorms at ~22.00 on December 22 and ~2.00 UT on December 23. The several features of the events observed by Tail and Auroral Probes are: (1) disruption of plasma sheet and neutral sheet current; (2) motion of plasmoid in the plasma sheet; (3) injections of ion and electron beams into the auroral region; (4) appearence of strongly enhanced energetic particle fluxes.

ST12 Theory and simulations of solar system plasmas

Convener: Büchner, J.
Co-Convener: Belmont, G.

SUBSTORM ONSET AS A TRANSITION TO GLOBALLY COHERENT RECONNECTION

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We show that micro-reconnection can always take place in magnetotail-like structures. Special conditions must be fullfilled, however, in order to allow a transition to large scale reconnection. The appearance of sufficient dissipation by wave-particle resonances or inertial effects causes the transition to large scale coherent reconnection. We demonstrate the possible evolutions toward large scale reconnection by means of kinetic simulations and derive resulting thresholds and criteria of substorm initiation.

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In a collisionless low-β plasma (β<<1), finite Larmor radius effects and electron inertia effects lead to the modification of the Alfvén wave into the so-called kinetic Alfvén wave. In their nonlinear regime, these dispersive waves may form Solitary Kinetic Alfvén Waves (SKAW). They take the form of a localized plasma compression or rarefaction. They are associated with a perpendicular electric and magnetic perturbation and with a parallel electric field. In the presence of a single electron population, they propagate either at the Alfvén velocity or at the ion-acoustic velocity. We studied SKAW in a two electron temperature plasma for an extended range of plasma parameters. It is shown that the inertia of the cold electron component allows the existence of compressive and rarefactive SKAW wich propagate at the electron-acoustic velocity. Similarly, thanks to the ion inertia and to the presence of the hot electron population, rarefactive ion-acoustic-like SKAW may exist in such a plasma. The parametric study of these structures shows the connection between these different kind of solitary waves and gives their typical electric and magnetic profiles. Possible applications of such theoretical studies to magnetospheric and solar physics will be set out.

REMOTE DETERMINATION OF RECONNECTION PARAMETERS BY THE ENERGETIC H^+, HE^{++} AND O^+ ION SPECTRA

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The time-of-flight spectrometer HEP-LD onboard GEOTAIL has measured the spectra of higher energy H^+, He^{++} and O^+ ions, flowing eartward and antisunward in the Earth magnetotail (cf. Zong et al., J. Geophys. Res., 1997; 1998). We show that the spectra can be well explained as being formed due to acceleration by magnetic reconnection. A fitting of the observed curves with the theoretically predicted spectrum allows the determination of major parameters of reconnection.

WAVE-PARTICLE INTERACTIONS TO BE MEASURED BY CLUSTER: MODELLING THE DWP PARTICLE CORRELATOR

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The Particle Correlator module of the Cluster DWP (Digital Wave Processing) experiment is designed to detect and measure modulations in the plasma electron population resulting from wave - particle interactions and short time particle bursts. The amplitude of modulation is measured as a function of wave frequency and electron energy using the auto-correlation technique. Results are presented of modelling the detection characteristics of the technique as implemented in the Cluster DWP instrument using idealised wave - particle interactions to simulate those which may be encountered by Cluster. Compared to E-field spectra, particle modulation spectra are in general difficult to interpret, the resonance peaks in frequency-velocity space for particles being generally less pronounced compared to the corresponding resonance peaks in frequency-wavenumber space for the associated wave E-field. Also discussed, therefore, is the general problem of identifying weak amplitude modulations and criteria that can be used to determine whether such modulations are significant in comparison to the every present random modulations resulting from plasma thermal noise and and instrumental effects.

KINETIC MODEL OF ALFVÉN WAVE LIGHT-ION GYRORESONANCE HEATING

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The absorption of Alfvén waves by gyroresonant interaction with the light-ions in an ionospheric oxygen-hydrogen plasma with parallel magnetic field gradient is reconsidered, taking into account simultaneously the plasma inhomogeneity and the finite temperature of the resonant ions ($T_i \neq 0$). A kinetic full wave equation is derived, that is valid in the vicinity where the wave frequency matches the local proton gyrofrequency. It is analytically solved for the case of a Lorentzian distribution function. The energy transmission, reflection and absorption coefficients, for waves incident from the high magnetic field side onto the gyroresonant interaction region, are found to be the same as for the cold plasma case ($T_i = 0$). Conversely, the absorption of waves incident from the low magnetic field side is found to be enhanced and strongly depends on the ionic temperature, whereas their transmission to the high magnetic field side occurs still in the same proportion as for the cold plasma case. Elaborating local dispersion curves and evaluating the full wave solutions enable us to interpret qualitatively these results and to extrapolate them for the case of a Maxwellian distribution function. For realistic ionospheric plasma conditions a sensible increase of the gyroresonant absorption of the waves is thus found.

THE STABILITY OF THIN CURRENT LAYERS FROM BIDIMENSIONAL HYBRID SIMULATIONS

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The stability of thin current layers embedded in sharp rotational or tangential discontinuities having widths of the order of the thermal ion Larmor radius is difficult to investigate theoretically. The frequent occurrence of such discontinuities in space plasmas fully justifies the attention recently paid to their stability. Two-dimensional hybrid simulations are used to demonstrate that sufficiently thin current layers can be unstable to surface modes propagating along the mean direction of the current in the layer. In isotropic plasmas, the only case that we have studied so far, this instability is controlled by the rotation angle of the tangential component of the magnetic field and the beta parameter of the plasma. The influence of the initial state of the simulated system on the results, as well as the controlling factors, will be discussed.

Nongyrotropic Ion Distributions in the Near-Earth Magnetotail

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We examine the transport of plasma sheet ions in the near-Earth magnetotail (10-15 R_E) using single-particle codes. In this region of space, because of Larmor radii comparable to the magnetic field line curvature radius, plasma sheet ions are subjected to a dynamical regime different from that in the distant tail or in the inner magnetosphere. Upon interaction with the current sheet, these plasma sheet ions may experience magnetic moment scattering and prominent bunching in gyration phase due to enhanced tailward oriented centrifugal pull. We focus on the consequences of this centrifugally-driven phase bunching. Within the limits of the calculations which do not treat the particle dynamics in a self-consistent manner, we show that this effect leads to a distinctive current distribution in the near-Earth tail, which is not found further out. In the equatorial vicinity, this distribution is characterized by a striated pattern of current both in the dawn-dusk and in the Earth-tail directions. The latter current leads to field line inclination in the dawn-dusk direction near the earthward edge of the magnetotail current sheet, which may be viewed as characteristic of this region of space. We also show that in this region, off-diagonal elements of the pressure tensor are essential to achieve stress balance, in a like manner to the distant magnetotail.

Stochasticity and trapping in single particle dynamics in slow and fast varying reversals.

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Single-particle dynamics in simple models for static reversing magnetic fields have been extensively studied analytically in the case where the reversing field varies, the linking field is constant, and the shear field is zero. More recently, some generalization to include time dependence has been achieved, and results for static reversals which include a constant shear component have been obtained. The principal motivation for these recent studies has been the static or dynamically thinning pre substorm magnetotail surrent sheet, however they are sufficiently general to permit assymetric fields (as in the magnetosheath) and relaxing rather than thinning reversals (as in rapid dipolarization of the magnetotail). Here we develop these more general results annd discuss their implications.

SMALL SCALE DENSITY GRADIENTS AS PREFERENTIAL SITES FOR THE DISSIPATION OF ALFVÉN WAVE POYNTING FLUX

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The role of small scale density inhomogeneities in the formation of parallel electric field is discussed. We use a simple two-dimensional model of the auroral plasma cavities and we study how Alfvén waves propagate in presence of the sharp density gradients that characterize the edges of the plasma cavities. Due to the combined effects of (1) the fast rotation of the phase plane of the waves and (2) the apparition of space charge on the gradients, high values of the parallel electric field arise (of a few mV/m for $E_\perp \sim 1$ V/m) where the density gradients are maximum. A detailled parametric study reveals that the spatial and time evolution of the parallel electric field is highly dependent on the initial perpendicular electric field shape and on the gradient size as well. The effects of the spatial/temporal variations of the parallel electric field on the distribution functions are then discussed.

FIELD-ALIGNED CURRENTS AND PARALLEL ELECTRIC FIELDS IN THE PLASMA SHEET BOUNDARY LAYER

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The magnetospheric convection electric field drives field-aligned currents in the plasma sheet boundary layer. The currents are non-ideal-MHD effects, of order of the ion mass to charge ratio in fluid theory. We present a fluid theory of the currents in a two-dimensional magnetic field model containing an X-type reconnection line. There are two contributions to the currents, both downward in the model solutions, one arising from finite Larmor radius physics and the other from the Earthward rate of change of the duskward ion drift velocity. In a uniform dawn-dusk electric field the largest ionospheric current density occurs on field lines for which the equatorial magnetic field is weak or has large curvature, on plasma sheet boundary layer field lines that lie near the separatrix. In principal, the current density is modified and limited by magnetospheric-ionospheric coupling; in practice, the ionospheric Pedersen conductivity is so high that the coupling has virtually no effect. The current into the ionosphere is of the order of 10^5-10^6 A, in accord with observations, the detailed value depending on the size of the diffusion region. Parallel potential drops, computed from the requirement of quasineutrality in the presence of ion vorticity, are of the order of 1 kV on plasma sheet boundary layer field lines in the magnetosphere, exclusive of any low-altitude contribution.

SATURN'S THERMAL PLASMA AND NEUTRAL CLOUD-RING COMPLEX

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From HST observations, it is now known that the Saturnian system is filled with a dense cloud which is supplied by the rings, icy satellites and Titan's exosphere. In the inner magnetosphere, collisional interaction of the charged E-ring particles with Enceladus and the ring system turns out to be very important in building up a gas disk of water-group composition. The plasma temperature between the rings and the orbit of Enceladus can hence be controlled by the collisional cooling of the neutrals. At the same time, the ion composition of the corotating plasma cloud could be largely determinded by the ionization and charge exchange process in the plasma disk. The spatial distribution of the water-group ions as a result of radial diffusion from their source region will be described. The implication of the dense neutral cloud on thr charge-exchange loss of the magnetospheric energetic ions will also be expored.

STATISTICAL PROPERTIES OF AMPLITUDES AND PHASES IN THE ENSEMBLE OF INTERACTING WAVES

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We study the statistical properties of nonlinear wave-wave interaction in an ensemble of several interacting waves. The system under consideration is supposed to have the energy source and dissipation in the form of the growth rate for one of the waves, and damping rate for the others. It represents either a cascade of several decay instabilities, or modified decay. We pay special attention to the effect of the transition from purely dynamic regimes of the systems behavior to the stochastization of phases. It is shown that the transition from the three wave interaction as a dominant process to the four wave interaction can be associated with the appearance of the phenomenon of chaotic synchronization. We consider several effects that can determine statistical properties of the system such as the presence of the external noise, detuning from the exact resonance, or the width of the spectral lines.

Two-dimensional models of the coronal magnetic field

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We simulate the large-scale structure of the magnetic field in the solar corona adjoining the chromospheric-coronal boundary outside supergranules using a 2-dimensional cylindrical current-layer approximation. The principal idea is that although the convection pattern responsible for producing the global magnetic field within the corona is unknown, its statistical features can be assessed: the number of supergranules is large enough to make such a statistical approach reliable. The large-scale magnetic field is assumed to be a superposition of small-scale fields resulting from supergranule currents located near the chromosphere-coronal boundary and obeying specified statistics together with a dipole field related to processes occurring deeper within the sun. Our analysis of the resulting magnetic field patterns reveals that they depend critically on the number of current 'jets' associated with the supergranules. This dependence is found to be qualitatively similar to the observed variation of the coronal magnetic field with solar activity. A second model is employed to simulate the fine structure of the field within a particular supergranule: here a plane current-carrying layer approximation is used with an externally-specified large-scale magnetic field as a fitting parameter. The escape of energetic particles from the chromosphere-coronal boundary is studied as an application of the model.

THREE DIMENSIONAL STUDY OF RECONNECTION IN THE EARTH'S MAGNETOTAIL

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We study the stability of the Earth's magnetotail using the implicit code CELEST3D. A realistic equilibrium including a perpendicular magnetic field is considered. The implicit formulation allows us time steps almost 100 times larger and grid spacings 4 times larger than required in explicit formulations: for the first time a large section of the magnetotail can be studied with a more realistic mass ratio of 180 and with sufficient accuracy in the particle velocity distribution (82 particles per cell per species).
The simulations show that magnetic reconnection in the magnetotail is due to a new 3D mode. In 2D simulations, the tearing and drift-kink mode could only be studied separately. In 3D systems a more general mode can exist with direction of propagation neither along nor across the direction of the plasma current. The new mode is linear in character and starts growing from the original configuration.
Note that this effect could not be described in previous models with lower mass ratios: the correct evolution of the 3D mode requires the tearing mode to grow more slowly than the drift-kink mode: an effect present only for realistic mass ratios.

CONVECTIVE INSTABILTY IN THE OUTER PLASMASPHERE

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The corotating plasmasphere is stable with respect to convective instability during quiet conditions. During substorms, this situation is changing: sunward and eastward magnetospheric convection is then suddenly enhanced in the post-midnight sector, beyond L>3. Consequently, centrifugal effects (influencing mostly the distribution of the cold exospheric plasma) are augmented in the post-midnight sector, for L>3; the total (gravitational + inertial) force acting on all ions is then lowered, and the initial equilibrium density distribution becomes convectively unstable in all magnetic flux tubes which are convected faster then before the storm onset; a flow of ionospheric H+ ion is driven upward as result of the now unbalanced kinetic pressure gradient. Thus the ionosphere gets depleted of its light ions content. All ions which are able to overcome the reduced potential barrier can accumulate in the equatorial potential well, beyond the "zero-parallel-force surface". These ions trapped in the equatorial potential well form there a cloud of cold (<10 e V) plasma (plasmoid) with a kinetic pressure exceeding that of the background. As a result of this excess kinetic pressure the plasmoid experiences cross-L interchange driven by magnetic forces; indeed, the eastward polarisation electric field generated by the opposite grad-B and curvature drifts of electrons and ions detaches it from the plasmasphere and drives it into the magnetotail where it produces significant diamagnetic effects.

ELECTRON ACCELERATION AT SHOCK WAVES IN THE HELIOSPHERE

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Shock waves are formed at different places in the heliosphere. They play an important role since they are able to accelerate particles up to high energies. For instance, such shock waves appear as solar type II radio bursts built up due to solar flares in the solar corona, as travelling interplanetary shocks, planetary bow shocks, and as pairs of forward and reverse shocks associated with CIR's. In some cases of these shocks electrons are accelerated up to suprathermal and, partly, relativistic energies. A summary of the plasma and particle measurements of these heliospheric shock waves will be presented. The inspection of these observational data show that even supercritical shock waves with large Alfvén-Mach numbers are able to accelerate electrons up to high energies. Finally, the mechanism of the shock drift acceleration and the Fermi process are presented and compared with the observations.

CONCERNING NONGYROTROPIC PARTICLE DISTRIBUTIONS IN SPACE PLASMAS

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In nonstationary and strong inhomogeneous plasmas particle orbits are rather complicated. When the nonstationary time scale is smaller than the gyration period or when the inhomogeneity scale is smaller than the gyration radius - that is at magnetic plasma boundaries - nongyrotropic distribution functions occure. The stability of such plasma configurations is studied in the framework of linearized Maxwell-Vlasov theory and by particle simulations. In nonstationary plasmas nongyrotropy drives unstable waves parallel as well as perpendicular to the background magnetic field whereas in the gyrotropic limit the plasma is stable. As an example of an inhomogeneous plasma a sheared magnetic field configuration or reconnection boundary is discussed. Particle and field distributions are described by a superposition of modes of different spatial scales and spatial filamentations. Excitation of unstable transverse waves occures at a sheet thickness in the order of the particles thermal gyration radius.

STATIONARY NONGYROTROPY NEAR COMETS

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Nongyrotropic unperturbed particle distributions are often derived as homogeneous solutions of the Vlasov equation for closed phase space (no source and sink terms) leading to a time-dependant structure of the solution (rotating at the gyrofrequency in velocity space). In the case of a weakly-active active comet, the introduction of a source (newborn ions) and loss (diffusion) terms leads to a stationary structure of the unperturbed nongyrotropy for the ion ring distributions, which provides a good agreement with the observations. Since the associated low frequency waves exhibit a compressive component on the magnetic field and the plasma density, the linear stability of the model distribution has been investigated for oblique wave propagation. The results show that the weak nongyrotropy observed in this case has little influence on the ring instability.

RESONANT AMPLIFICATION OF MAGNETOSHEATH WAVES AT MAGNETOPAUSE: MAGNETIC FIELD EFFECTS

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Previous studies have shown that a high level of electromagnetic fluctuations is observed at the magnetopause and that it might be explained by a resonant amplification of waves coming from the adjacent magnetosheath. The first model developed has included the density gradient which is observed near the magnetopause, in the cold plasma MHD context. Successive improvements have now been added: the effects of ion inertia (which allow a study up to frequencies of the order of the proton gyrofrequency) and the effects of plasma temperature. The results obtained in this more realistic description happens to be quite different: the resonances that were observed in the most simple case disappear and the incident fast waves are converted into Alfven waves propagating backward. A further study indicates that the magnetic field rotation then becomes a fundamental ingredient, although difficult to handle. The reflected Alfven waves are trapped in the boundary between the conversion point and the point where they propagate perpendicularly to the static magnetic field. This explains the high level of fluctuations observed in the boundary and their Alfven-like polarisation.

MODELLING COLLISIONLESS PLASMAS NEAR A POTENTIAL WELL : THE EXAMPLE OF THE IO PLASMA TORUS

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The passage of the Ulysses spacecraft in the "Io plasma torus" has invalidated the traditionnal hypothesis of the local diffusive (isothermal) equilibrium along the magnetic field lines, actually showing that the electron temperature was substantially increasing along these lines. To explain this observation, we refer to a "velocity filtering" mechanism, firstly proposed by J.D. Scudder [*Astrophys. J., 398*, 299, 1992] in the context of stellar coronae. This mechanism acts as a high pass filter for particle energies if the particles are confined in an attracting monotonic potential and have a non-maxwellian velocity distribution. These conditions are met in the Io torus, where there is an attractive potential due to the centrifugal force (since the torus is corotating with Jupiter) and where each particles species has a suprathermal component with a velocity distribution roughly decreasing as a power law; in this case, frequently met in collisionless plasmas, the velocity distribution of particles can be conveniently modelled using a " kappa " distribution. Finally, because the torus ion distributions could have a strong temperature anisotropy, we build a kinetic collisionless model of the Io plasma torus based on "anisotropic bi-kappa" distributions, which explains most of the observed latitudinal variations of the densities and temperatures in such a confined plasma.

RESONANT ENHANCEMENT OF RELATIVISTIC ELECTRON FLUXES IN GEOMAGNETIC STORMS.

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Enhancement of energetic electron fluxes at L ~ 4-5 were observed during geomagnetic storm intervals, as well as during quieter times following high speed solar wind stream arrival at 1 AU. Consecutive passes of GPS satellites showed an increasing flux of 1.6-3.5 MeV electrons for the January 10-11, 1997 storm event, as well as increase at L=4.5 of < 1 MeV electrons which precedes increase in the > 1 MeV, without significant flux increase initially at higher L values. This observation, and others by HEO spacecraft suggest that a local heating mechanism may be operative. It is suggested that the ubiquitous, obliquely propagating whistler waves interact with electrons which bounce along the geomagnetic field lines. The unducted whistler chorus which is a typical signature of the substorm expansion phase, interacts with the seed of sub-relativistic electrons. For an oblique wave propagation the energetic electrons with large gyroradius (larger than the perpendicular wavelength) can interact resonantly with multiple harmonics of the whistler waves on their bounce trajectories along the inhomogeneous magnetic field. The resulting resonant interaction violates the first and the second adiabatic invariants and results in electron energization at relativistic energies. The analysis of the energization with the help of particle and Hamiltonian simulations of these interactions are presented.

VLASOV SIMULATIONS OF VERY WEAK DOUBLE LAYERS; APPLICATION TO THE SOLAR WIND

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Very weak double layers have been recently observed in the Solar Wind; their properties are compatible with weakly nonlinear ion-sound waves, and they are most probably related to the interplanetary potential which is responsible for maintaining the electric neutrality of the solar wind plasma. With the help of a Vlasovi-Poisson simulation in one and two dimensions, we study the stability of a plasma submitted to an imposed, weak, electric field in conditions similar to those found in the fast solar wind. One observes a regime where no time independant solution can be found, characterized by running weak amplitude perturbations similar to those observed in the solar wind. The relation with these observation are discussed.

INJECTION AND ACCELERATION OF PICKUP IONS AT INTERPLANETARY SHOCKS

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It has recently been pointed out by Giacalone et al. (1997) that pickup ions are more efficiently accelerated at interplanetary propagating shocks than at stationary shocks. like planetary bow shocks and the heliospheric terminating shock. This demonstrates the potential importance of interstellar pickup ions as fundamental contributors to energetic particles in the heliosphere. We have investigated the condition for acceleration of pickup ions at the shocks bounding corotating interaction regions (CIR's) as a function of radial distance. Using a simple hydrodynamic scheme with spherical symmetry we follow the radial evolution of the shock propagation speed as well as the radial change of the solar wind velocity upstream of the CIR shocks. We then calculate the Parker spiral angle of the IMF and the local shock normal direction from which we obtain the shock angle Θ_{Bn}. We have investigated the conditions for reflection and injection of pickup ions at oblique shocks bu self-consistent hybrid simulations. Based on these results we propose a model where pickup ions are preferentially injected and accelerated in the inner solar system. Beyond 4 AU accelerated pickup ions should only be present well within the CIR on field lines which map to the shocks closer to the Sun. where the shock angle Θ_{Bn} is smaller.

LOW-FREQUENCY ELECTROMAGNETIC WAVES CAUSED BY SMALL-SCALE BI-ION INTERACTION

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The interaction of the solar wind with a weak heavy ion source of an extension smaller than the gyroradius of the pick-up ions creates a beam-plasma configuration: Solar wind protons move relative to the heavy ions which can be considered as unmagnetized. Such situations are typical for comets with low gas production rates ($q \leq 10^{27}$ s^{-1}), non-magnetized planets (Venus, Mars), active moons including their gas tori (Phobos, Deimos) and active experiments (AMPTE). Dispersion analysis on the basis of Hall-MHD equations gives that two types of low-frequency electromagnetic waves are excited having maximum growth rates at off-propagation to the magnetic field. The 'upper' instability occurs in the whistler branch, which in the beam frame is shifted down to about the proton cyclotron frequency. The 'lower' instability is determined by the cut-off frequency of the bi-ion system. Both lines were clearly seen in the spectra of magnetic field data obtained onboard the *PHOBOS* spacecraft, especially during crossing of the gas/dust torus of the moon Phobos, and at the AMPTE Ba/Li releases. Thus, the analysis of low-frequency electromagnetic waves allows the diagnostics of small-scale bi-ion effects which can sufficiently be described by fluid models.

THEORY AND SIMULATION OF 3D RECONNECTION IN SOLAR FLARES

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Some new theoretical and numerical results concerning the study of 3D magnetic reconnection in the solar flares are reviewed. The collisionless reconnection theory – more exactly, the model of a high-temperature turbulent-current non-neutral current sheet – is applied to the coronal conditions derived from solar observations with the Hard X-ray Telescope (HXT) and the Soft X-ray Telescope (SXT) on board *Yohkoh*. New theoretical interpretations are discussed of the *Yohkoh* and correlated multi-wavelength radio data on the site and mechanism of magnetic energy transformation into kinetic and thermal energies of superhot plasmas and accelerated high-energy particles. The idea of impulsive two-step acceleration in flares is advocated.

NONLINEAR DYNAMICS ASPECTS OF MAGNETOSPHERIC ACTIVITY

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Models of substorm-related magnetotail dynamics are discussed from the point of view of nonlinear dynamics. The discussion involves a survey on theoretical and numerical results and, in particular, on bifurcation properties of magnetotail equilibria. It is neither a transition from stable to unstable equilibria nor a catastrophe in its standard understanding. It is suggested that the actual process seems to be of a different nature, and that it involves properties typical for plasmas. Possibly this is the reason why it does not seem to play an important role in classical nonlinear dynamics.

The results on which this lecture is based were in part obtained in collaboration with Prof. Dr. Alexey Kropotkin, and Dr. Oleg Trubachev (Institute of Nuclear Physics, Moscow State University, Moscow, Russia).

KINETIC/INERTIAL ALFVÉN WAVES IN THE EARTH'S MAGNETOSPHERE

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There is growing evidence that Alfvén waves with short perpendicular scales play a major role in the physics of various magnetospheric phenomena. A proper description of these waves cannot be made within MHD approximation, but must include thermal (ion kinetic) and electron inertia effects in the dispersion equation. We present a review of recent progress in the theory and applications of kinetic and inertial Alfvén waves. A new, recently emphasized effect is that inertial Alfvén waves propagate along a (resonance) cone angle, creating spatial channels where most of the wave energy is concentrated. It is believed that optical discrete auroral arcs with thickness of $\sim$ 1 km are related to such channels induced by Alfvén cones. The inertial waves carry substantial parallel electric field which induces a number of nonlinear plasma effects. One such an effect is related to cavitation of magnetospheric plasma produced by ponderomotive force of Alfvén waves.

A NEW MECHANISM OF A SOLAR FLARE

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A new mechanism of a solar flare is suggested which is based on explosive deveolpment of the cyclotron instability (CI) of energetic electrons trapped by the coronal magnetic field. At the preflare stage, the change of topology of the coronal magnetic field in an active region leads to accumulation of energetic electrons in the magnetic trap together with growth of the density and cooling of the background plasma caused by the increase of the radiation losses. A flare appears at first in a very local region of the magnetic flux tube (as a rule, at the central cross-section) where CI threshold which is determined by the electron-ion collision frequency is minimal. CI develops as an explosion due to the very fast nonlinear decrease of CI threshold connected with the intense heating of the background plasma by cyclotron waves. The very high power density of the explosion is achieved because the energy of energetic electrons from the total volume of the magnetic trap is transformed to the background plasma via cyclotron waves in a very small piece of the magneic flux tube. When the plasma pressure overtakes the magnetic pressure, the ejection of this hot plasma toward the external corona and interplanetary space begins. Under this scenario the soft X-rays are due to the thermal emission of plasma heated to the temperature 10^7–10^8 °K, and hard X-rays are due to the bremstrahlung of energetic electons precipitated into the photosphere. Quantitative estimations are in good accordance with the observations.

IMPLICIT PIC SIMULATIONS OF THE FARLEY-BUNEMAN INSTABILITY

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The *Farley-Buneman*-instability (FBI) in the *E*-region of the ionosphere is well known from observations for many years now and is well understood in its linear regime. The nonlinear processes that lead to saturation of the FBI and to electron heating at auroral latitudes, however, are difficult to observe.
Theoretical treatment of nonlinear effects usually makes simplifications of some kind to find analytical solutions and doesn't describe the whole range of physical phenomena at a time.
Computer simulations provide an excellent means for studying such basic problems in plasma physics. In this way all data are directly accessible, making it possible to identify the physical processes leading to saturation. The standard particle-in-cell (PIC) codes, however, are too strongly limited in their temporal and spatial range by numerical stability constraints. Therefore, a more advanced, direct implicit method was employed. Unlike previous work, this method made it possible to use the real mass ratio of electrons and ions instead of an arbitrary ratio of 100, leading to more realistic models. Results of these simulations will be presented and discussed.

MAGNETOSPHERIC TRANSPORT IN LÉVY FLIGHT STATISTICAL MECHANICS

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Transport in collisionless plasmas is an important and so far unresolved problem. In the classical picture it requires the generation of anomalous transport coefficients. Such coefficients are based on the assumption that high wave intensities scatter particles in pitch angle and energy thereby causing braking their motion and leading to enhanced transport. New developments in the theory of collisionless statistical mechanics suggest that a new thermodynamically stable state can be generated in such circumstances. This state allows for correlative couplings of large groups of particles which undergo Lévy flights. As consequence modified transport coefficients are generated. Tentative application to problems in collisionless plasmas like the magnetosphere suggest that such flights may be of importance for the dynamics of the boundary layer and plasma sheet plasma during quiet and disturbed conditions. Anomalous collision frequencies can be orders of magnitude higher than in classical cases.

NEW ASPECTS OF PLASMA SHEET DYNAMICS: MHD AND KINETIC THEORY

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Dynamical processes in the near-Earth plasma sheet are of fundamental importance in the context of magnetospheric activity. Dramatic substorm signatures during late growth phase and expansion phase are found in the near-Earth tail inside $10R_E$. In my talk, I will review numerical simulations considering the dynamics of the near-Earth plasma sheet. In this context, onset and nonlinear evolution of magnetic reconnection and the development of thin current sheets are of special interest. Those thin current sheets are discussed as a possible cause of microscopic fluctuations acting as collective non-idealness from a macroscopic point of view. The origin of macroscopic local non-idealness is of crucial importance for the onset of reconnection in the, in general, highly ideal magnetospheric plasma. In the second part of my talk I want to outline the concept of a self-consistent theory that allows to calculate macroscopic non-idealness as result a strongly fluctuating, mixing dynamics on microscopic scales. One important advantage of this theory is, that one has not to care about the specific nature of the microscopic fluctuations. Implementing these resulte into MHD-simulations will allow to consider self-consistently derived macroscopic non-ideal consequences of microscopic fluctuations.

EXACT AND APPROXIMATIVE SOLUTIONS OF THE PLASMA EQUILIBRIUM WITHIN THE MAGNETIC FIELD OF A PUNCTUAL DIPOLE

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For a axial symmetry, we report upon analytical solutions of MHD equilibrium of a plasma within the magnetic environment of ponctual dipole. Inside the plasma domain, we calculate the magnetic flux for a given shape of the pressure profile. Another magnetic flux is derived outside the plasma domain where the pressure is null. Both functions and their normal derivatives are continuous through the frontier between the two domains; together they constitute the solution of our problem. In a first case, we use a pressure profile which is quadratic function of the magnetic flux. It leads to an exact solution which is a simple function of the spherical coordinates. We show that, in this situation, the plasma energy is distributed over the entire plasma domain. This solution is well appropriate to magnetospheric studies. In another case, we assume that the pressure profile is forth power of the magnetic flux. Then the solution exhibits localized states, particularly for the plasma energy which is concentrated near the dipole. We note that the magnetic flux determined outside the plasma domain is expressed by very general formulae, which is valid for a wide class of both, the pressure profiles and the shape of plasma exterieur frontier. Far away from this frontier, like near the coordinate center, the magnetic field tends to be dipolar.

RELATIONSHIP BETWEEN CME AND PROMINENCE

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Observations of an eruptive prominence were obtained on May 1, 1996, with the instruments aboard SOHO during the preparatory phase of the Joint Observing Programme JOP12. A coronal mass ejection observed with LASCO is associated temporally and spatially with this prominence. We will discuss on the physical conditions of the prominence derived from the spectrometers SUMER and CDS. The CME observed by LASCO left the corona some tens of minutes before the prominence erupted. This is evidence that the prominence eruptions are probably the result of the removal of the restraining coronal magnetic fields which are in part responsible for the original stability of the prominence.

SOLAR WIND - EARTH MAGNETOSPHERE COUPLING

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The problem of solar wind and / or ionosphere contribution to the dynamics of magnetosphere during disturbed periods is open. The object of the study is proton/electron solar wind entering the magnetosphere under different interplanetary conditons.3D e.m. particle code TRISTAN (Buneman,1993,Nishikawa,1997) is used. The simulation box is 65x35x35,time step is 4s. The potential of the code in reproducing quiet magnetosphere field/particles distributions is illustrated. Varying interplanetary magnetic field vector and solar wind bulk velocity are applied to investigate intensity and geometry of the entry. It is shown the details of solar wind entering depend on IMF orientation rather than on the solar wind bulk velocity.

ST13 The Sun: SOHO and related results

01 Plasma diagnosis of the solar atmosphere by photon spectroscopy and remote particle measurements

Convener: Hilchenbach, M.
Co-Convener: Hansteen, V.

ISOTOPE FRACTIONATION PROCESSES IN THE SOLAR WIND

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With the availability of new data from solar wind mass spectrometers with greatly improved mass resolution and in view of the upcoming GENESIS mission which has the purpose to determine solar isotope abundances applying the foil collection technique to solar wind ions, it has become important to study all relevant fractionation processes which might play a role on the way of particles from the solar atmosphere to the interplanetary plasma. We summarize evidence for secular gravitational settling and concomitant isotope fractionation in the outer convective zone. Furthermore, we estimate the importance of fractionation in the chromosphere and in the inner corona. due to inefficient Coulomb drag. Finally, we make an attempt to assess isotope fractionation processes in a corona with very hot ion temperatures and with strongly anistropic velocity distributions.

THE INFLUENCE OF SUPRATHERMAL ELECTRONS ON THE DERIVATION OF CORONAL ELECTRON TEMPERATURES FROM SOLAR WIND MINOR ION CHARGE STATE SPECTRA OBTAINED FROM SOHO/CELIAS/CTOF

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The SOHO/CELIAS/CTOF (Charge Time Of Flight) mass spectrometer measures the ionic and elemental composition of minor ions in the solar wind. From density ratios of adjacent charge states of minor ions we derive, consistent with previous measurements of the same type, mean freeze-in temperatures in the slow solar wind ranging between about 1.1×10^6 K and 1.6×10^6 K depending upon the charge states and elements considered. These values are obtained by assuming a Maxwellian distribution of the electrons in the inner corona. We assess the influence of suprathermal electrons in the corona upon the density ratios and, subsequently, on the temperature estimates that are drawn from minor ion charge spectra.

THE ELECTRON TEMPERATURE IN THE SOLAR CORONA AND CHARGE STATES IN THE SOLAR WIND

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We review measurements of charge state distributions of minor ions in the solar wind and discuss their implications for the coronal temperature. The formation of charge state distributions of heavy ions in the corona and the solar wind is dominated by ionization and recombination through collisions with electrons. As the rates are proportional to electron density, they decrease with the expansion of the solar wind and the charge states freeze in within a few solar radii. The resulting charge state distributions are transported essentially unaltered by the solar wind and can be observed by mass spectrometers on spacecraft like ULYSSES, WIND, or SOHO. Measured ratios of adjacent charge states can be used to infer the so-called freeze-in temperatures. These temperatures depend on the element and on the type of solar wind and have been interpreted as a measure of the coronal electron temperature in the freeze-in region. As the freezing-in process is gradual, the result depends on the radial profile of electron density, electron temperature and ion velocity in the relevant solar wind flux tube. The electron temperature in the solar corona can also be inferred from optical observations. The electron temperatures determined by ratios of optically thin EUV lines are compared to the solar wind observations. We also discuss the importance of non-Maxwellian electron distributions and differential streaming of ions.

ELECTRON ACCELERATION IN THE ONSET PHASE OF CORONAL MASS EJECTIONS: IMPLICATIONS FOR THE STRUCTURE OF THE SOLAR CORONA FROM OBSERVATIONS OF THE SOHO SPACECRAFT AND GROUND BASED RADIOWAVE MEASUREMENTS

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We have correlated MeV electron measurements in solar particle events (SPEs) measured with the COSTEP experiment onboard the SOHO spacecraft with white-light observations of the solar corona provided by SOHO's LASCO experiment. From the CMEs' height-time evolution we find that in events with good magnetic connection to the CMEs' source regions, the first particle acceleration processes typically occurred when the CMEs had reached specific heights in the low corona. These heights were compared with the height-time evolution of associated type II bursts measured with the Potsdam radiospectrograph. Implications for the large-scale structure of the lower corona and its electron density and temperature distribution will be discussed.

THE PROVISION OF ATOMIC DATA AND ESTIMATIONS OF ACCURACY

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In recent years, the quality and resolution of observational data has so improved that the accuracy of atomic data is frequently the limiting factor in progress. It is therefore imperative not merely that atomic data of improved accuracy are determined, but that a realistic assessment of that accuracy is provided. We will discuss various indicators of accuracy, for transition probabilities and cross sections, and how semi-empirical improvements can be made to refine ab initio results from already extensive calculations.
The main points will be illustrated with data from relevant atomic transitions.

THE SEARCH WITH CELIAS/CTOF FOR O^{6+} AS A SOLAR WIND CONSTITUENT

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The correlated measurements of the solar corona by optical and particle instruments that have been one purpose of the SOHO mission have yielded a striking conflict in the values of coronal electron and ion temperatures derived by different methods. As one possible reason deviation from local thermal equilibrium is considered. Under this assumption the otherwise not explainable formation of O^{5+} out to then frozen-in charge status of the solar wind might become existent. In this presentation we report of a thorough search of 5 months of data for evidence of this key ion.

SOLAR WIND ISOTOPIC ABUNDANCE RATIOS OF NE, MG, AND SI MEASURED BY SOHO/CELIAS/MTOF AS DIAGNOSTIC TOOL FOR THE INNER SOLAR CORONA

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Using the high-resolution mass spectrometer CELIAS/MTOF on board SOHO we have measured the solar wind isotopic abundance ratios of Ne, Mg, and Si in different solar wind regimes with bulk velocities ranging from 330 km/s to 650 km/s. Data indicate a systematic depletion of the heavier isotopes in the slow solar wind compared to their abundances in the fast solar wind from coronal holes. These variations in the solar wind isotopic composition represent a pure mass-dependent effect because the different isotopes of an element pass the inner corona with the same charge state distribution. The influence of particle mass on the acceleration of minor solar wind ions will be discussed in the context of theoretical models and recent optical observations with other SOHO instruments.

KINETIC PROPERTIES OF OXYGEN, SILICON, AND IRON IONS MEASURED WITH SOHO/CELIAS

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Observations of the mass spectrometer CELIAS/CTOF and of the CELIAS/PM sensor onboard the SOHO spacecraft are used to revisit drift speeds and kinetic temperatures of minor ions in the solar wind near solar minimum. For the case of a collision dominated plasma, minor species are expected to have approximately equal speeds as protons and to have equal kinetic temperatures. On the other hand, approximately equal thermal speeds are expected for a plasma which is energized by wave-particle interaction. Due to the large geometric factor and the 100% duty cycle of CTOF, excellent counting statistics for minor species is obtained and the kinetic properties of minor species can be derived with significantly improved time resolution. This allows a better distinction of effects related to varying drift speeds, influencing the observation of thermal distributions of rare ions.
Preliminary results confirm earlier work, showing excellent correlations among the drift speeds of minor ions. During periods of low kinetic temperatures the efficiency of adaptation of minor ions to local conditions appears to be ordered according to the m/q ratio of a given species.

TEMPERATURE OF THE SOURCE REGION AS DERIVED FROM HIGH RESOLUTION IONIC CHARGE MEASUREMENTS WITH SEPICA/ACE

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We present new results of high resolution ionic charge measurements in gradual solar energetic particle events. The measurements have been made with the Solar Energetic Particle Ionic Charge Analyzer (SEPICA) on the Advanced Composition Explorer (ACE) launched in August 1997 and cover the energy range $\approx$ 0.2 - 1.3 MeV/nuc (for oxygen). The new measurements provide for the first time abundances of individual charge states in the mass range 4 - 20 and at higher masses an ionic charge resolution that is significantly better than in previous measurements. The ionic charge distributions will be used to derive the temperature of the source region of the particles.

SOLAR WIND THEORY - IN LIGHT OF RECENT OBSERVATIONS

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In this presentation we will discuss the basic physics of the corona/solar wind system, and how recent observations can be used to place constraints on the energy deposition in the corona.

EFFECTS OF PLASMA FLOWS CONFINED IN CORONAL LOOPS ON SOHO OBSERVATIONS

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We investigate the deviations from ionization equilibrium induced by stationary plasma flows confined in coronal loops and their effects on the UV and EUV emission lines observed by the instruments on board SOHO. To synthesize the emission lines, we use a rather complete model of coronal loop hosting a siphon flows which take into proper accounts thermal conduction, radiative losses, and local energy input, together with the effects of gravity. We present here results on the detailed synthesis of loop emission in specific bands and lines observed by SOHO, taking into account the non-equilibrium of ionization, obtained with the use of ASAP, a powerful presentation system for astrophysical plasmas.

HIGHLY ENERGETIC ELECTRONS ACCELERATED BY CORONAL SHOCK WAVES

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Combined SOHO and ground based radio observations show evidently signatures of electrons accelerated by a coronal shock wave during the event on July 9, 1996. A solar type II radio burst has been received as a signature of a coronal shock wave by the radiospectralpolarimeter (40–800 MHz) of the Astrophysikalisches Institut Potsdam at 300 MHz on 9:10:54 UT. It was accompanied with electron beams appearing as type III radio bursts below 80 MHz. Simultaneously, the COSTEP instrument aboard SOHO has measured enhanced electron fluxes in the range 30 keV – 7 MeV. This indicates that a shock wave travelling with a velocity of 1300 km/s through the corona was able to produce highly energetic electrons.
A mechansim of electron acceleration up to relativistic energies is presented and compared with the observations. The electron acceleration takes place at substructures of quasi-parallel collisionless shocks. Large amplitude magnetic field fluctuations are these substructures in the up- and downstream region of the related shock.

UVCS OBSERVATIONS OF POLAR REGIONS

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UVCS observations of polar regions provide a wealth of information on the physical conditions of the solar plasma at heliocentric heights which, so far, have been little explored. Knowledge of the physical parameters in these regions is crucial to understand how the extended corona is heated and the solar wind accelerated. UVCS data, relevant to these issues, will be revued and their implications for solar wind modeling will be briefly illustrated.

ION TEMPERATURES IN A SOLAR POLAR CORONAL HOLE OBSERVED BY SUMER ON SOHO

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The temperatures of some highly charged ions in the southern solar polar coronal hole are determined from the widths of the EUV lines measured by the SUMER instrument on SOHO. Radiations from both light ions, such as Ne^{6+}, Ne^{7+}, Mg^{7+}, Mg^{9+}, Si^{6+}, Si^{7+} and heavy ions, such as Fe^{8+}, Fe^{10+} and Fe^{11+}, are recorded from off-limb observations. We refer here to the limb as the height, h_0, where the limb brightening of the N IV 765 Å line maximizes. After correction of the measured line widths for instrument contributions, the intrinsic widths of these emission lines are due to thermal motions of the ions and turbulent wave motions of the background plasma. The average temperature of Ne VIII, at heights above the southern limb relative to h_0 from 17″ to 64″, ranges between 1.3 and 5×10^6 K and of Ne^{6+} between 1 and 4×10^6 K. It is found that the ion thermal speed decreases with increasing mass per charge, while the ion temperature remains roughly constant. In another observation at heights from 167″ to 183″ above h_0, the temperature of the ions slightly increases with increasing mass per charge, while the thermal speed reveals no clear trend. The upper limits of the turbulence amplitude, $< \delta v^2 >^{1/2}$, as derived for these two altitude ranges, are 33-37 and 44 km s^{-1}, respectively.

SOHO OBSERVATIONS OF THE OUTER SOLAR ATMOSPHERE: STATUS AND PROSPECTS

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We present and discuss some of the main observational results recently obtained by the coronal remote-sensing instruments on board the SOHO satellite (CDS, EIT, LASCO, SUMER, UVCS). We concentrate, in particular, on the contribution given by these observations to a more detailed understanding of the physical conditions in the solar chromosphere, transition region and corona (temperature, density, flow velocity, chemical composition, magnetic configuration and so on). Some emphasis is given to the measurements of emission EUV line profiles (shape, width, Doppler shift) and to their importance for investigating the dynamical nature of the solar atmosphere plasma. We also present some results got in the extended corona concerning line intensities and profile which can be important for the understanding of the solar wind heating and acceleration processes. These results, coupled to plasma diagnosis with in-situ particle instruments, can help to establish the nature of the relationship between conditions in the regions of origin of the solar wind and the plasma flow properties observed at 1 A.U.

THE SOLAR CORONA ABOVE POLAR CORONAL HOLES AS SEEN BY SUMER ON SOHO

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Electron temperatures and ion velocities in plumes and inter-plume regions of polar coronal holes are deduced from ultraviolet observations of SUMER. We find the electron temperature, T_e, to be less than 0.6 MK in a plume in the altitude range from $r = 1.03$–$1.60\ R_\odot$ and to decrease with height to ≈ 0.3 MK. Near an inter-plume lane, the electron temperature is also low, but stays between 0.5 and 0.6 MK in the same height interval. O VI line widths in plumes are narrower ($\Delta\lambda_D \approx 150$ mÅ, $v_{1/e} \approx 43$ km s^{-1}) than in inter-plume lanes (≈ 190 mÅ, $v_{1/e} \approx 55$ km s^{-1}). The thermal and turbulent ion speeds of Si^{7+} reach values up to ≈ 80 km s^{-1} in the darkest regions above the coronal hole. This corresponds to a kinetic ion temperature of 1×10^7 K. A limit of ≈ 18 km s^{-1} for the bulk speed in plumes below $r = 1.2\ R_\odot$ is deduced from O VI line shifts measurements and consideration of the three-dimensional plume geometry (differential line-of-sight velocities $\lesssim 3$ km s^{-1}), whereas differential line-of-sight velocities of Mg^{8+} ions up to 34 km s^{-1} can be seen in dark regions.

THE SILICON, OXYGEN, AND IRON ABUNDANCE IN THE SOLAR WIND

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The CELIAS instrument onboard the SOHO satellite is designed to study the ionic, elemental, and isotopic composition of solar wind ions and of solar energetic particles. With the MTOF sensor (Mass Time-of-Flight) of the CELIAS instrument we can measure the elemental and isotopic composition in the main energy range of the solar wind (slow and fast) with high mass and time resolution. We will present data of the elemental abundance of oxygen, silicon, and iron solar wind ions. These three elements span almost the full mass range of the minor ions in the solar wind. Furthermore, this selection contains low and high ionization potential elements, allowing for a detailed study of abundance variations depending on the type of the solar wind.

ST13 The Sun: SOHO and related results

02 Multi-wavelength observations of solar atmospheric structure, evolution and eruptions

Convener: Harrison, R.A.
Co-Convener: Delaboudiniere, J.-P.

LASCO AND UVCS OBSERVATIONS AND CHARACTERIZATION OF A STREAMER CME ON 13-14AUG97

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The Large Angle Spectroscopic Coronagraph (LASCO) instruments observed a low-velocity streamer blow-out type Coronal Mass Ejection (CME) on 13-14Aug97. At the same time, the Ultraviolet-Coronagraph Spectrometer (UVCS) instrument was conducting streamer studies and observed the CME from 1.5 to 8 solar radii. Data from the two instruments have been combined to examine the 3-dimensional structure and velocity of this CME. The UVCS data show no evidence of cool material in this event. Both the LASCO and UVCS data suggest that all of the material in the CME came from a pre-existing streamer. LASCO and UVCS are instruments on the Solar and Heliospheric Observatory which is a mission of international cooperation between ESA and NASA.

MULTI-WAVELENGTH ANALYSIS OF INTENSITY DISTRIBUTION IN BRIGHT POINTS

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Bright Points, small and short lifetime structures, appear permanently in the solar atmosphere and could be considered as intermittent energetic bursts. They could be the result of the superposition of non-observable small scales events, characterized by an intensity distribution that follows a power law, as obtained in Self Organized Criticality models. Bright Points have been observed between June and November 1997, with CDS and SUMER on-board SOHO, in several lines formed at different temperatures. We have performed a statistical analysis in order to determine the coefficients of such power laws, as a function of the temperature of lines formation. These coefficients will be discussed in term of energy release.

THE EUV SOLAR IRRADIANCE SPECTRUM OBSERVED WITH CDS ON SOHO

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The solar extreme ultraviolet (EUV) irradiance is important for upper atmospheric studies as it is the dominant source for heating and ionization at altitudes above 90 km. A calibrated solar EUV irradiance spectrum in the range 307–380 Å and 515–632 Å is presented. The "*Sun as a Star*" spectrum was recorded by the Coronal Diagnostic Spectrometer (CDS) on SOHO on May 15 1997 using the normal incidence spectrometer (NIS) with a spectral resolution between 0.3 and 0.6 Å. The full disk spectrum is compared with simultaneous well calibrated EUV irradiance measurements from a LASP rocket payload. The present spectrum includes emission lines formed in the temperature range 10^4 to over 10^6 K, many of them suitable for plasma diagnostics. Line fluxes for the most prominent lines are extracted for the calibration and for the solar irradiance studies. This measurement should represent well solar minimum conditions as the daily 10.7 cm radio flux was 73 (units of 10^{-22} W m^{-2} Hz^{-1}). The relatively high spectral resolution, compared to other irradiance experiments, allow the separation of blends and the differentiation of weak emission lines and the continuum emission.

BRIGHT EUV SUNSPOT PLUMES EXIST

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During the *Skylab* mission considerable attention was given to bright plumes of EUV line emission in the atmosphere overlying sunspot umbrae. However, observations with the UVSP instrument on the *Solar Maximum Mission - SMM* led to the conclusion that the umbral transition region is generally indistinguishable from the quiet transition region. Based on observations of nine different sunspot regions with the Coronal Diagnostic Spectrometer - CDS on SOHO we find bright EUV sunspot plumes in five regions. In the other four regions the brightest line emissions may appear inside the sunspot but are mainly concentrated in small regions outside the sunspot areas.

MULTIPLE FLOWS IN THE ACTIVE REGION NOAA 7995

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The high spatial and spectral resolution of SUMER allow us to study in detail the profile of emission lines formed at different temperatures within the transition region. Based on observations of the active region NOAA 7995 on 17 November 1996 we investigate line profiles that deviate significantly from a single Gaussian. One possible interpretation of the complicated line profiles is an extremely structured transition region. By comparing emission line profiles formed at different temperatures within the transition region we explore possible explanations, such as, two or more siphon flows within the same spatial resolution element, line shifts caused by nonlinear Alfvén waves and bi-directional plasma jets.

CLASSIFICATION OF CORONAL MASS EJECTIONS IN REGARDS TO THE SOHO NEW VIEW

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In regards to the new view of the sun provided by SoHO, we can have some new information about the Coronal Mass Ejections. It's the first time that we can see a CME evolving from the photosphere to the far corona. We tried to observe them as frequently as possible with EIT, LASCO, and other terrestrial instruments. We made a morphological classification of this phenomenon. It seems that three types of CME's appear. We compare these results to the previous analyses of CME's.

NEW RESULTS ON THE SITE OF INITIATION OF CORONAL MASS EJECTIONS

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The place of origin of coronal mass ejections (CMEs) are streamer belts with a neutral line (NL) and streamer chains (or streamer belts without a NL). In some months during 1985–1987, up to 80-90% of the total number of CMEs were produced near streamer belts with a NL. As one approaches maximum solar activity, along with an increase in the number of CMEs, the proportion of CMEs places of origin lie near streamers chains is as high as 80% . Because of the inaccuracy in determining the longitude, some CMEs can be referred to both categories. Then the CMEs whose places of origin can be associated solely with streamers chains will make up 20-25%. Transformation processes of streamer belts with NL and streamer chains and also processes of disappearance and formation of streamer chains are likely to be an important factor contributing to an enhancement of CME generation.

ON THE POSSIBLE RELATION BETWEEN THE CHANGES OF CORONAL HOLES, CORONAL MASS EJECTIONS AND LARGE GEOMAGNETIC STORMS

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It is shown that the magnetic Storm Sudden Commencement (SSC) can be preceded by the following effects in the dynamics of coronal holes (CH): - correlated changes in the configuration of neighbouring CH which show up as a decrease of the distance between the opposite boundaries or parts of these boundaries of two CH and as the subsequent restoration by these boundaries (or their portions) of a state similar to the original one; - the appearance of a new transient or longlived CH. These effects reveal themselves most vividly in 41% of the events under consideration. The effects detected in the CH dynamics correlate well with qualitative concepts of the manner in which the magnetic field topology changes in the region of coronal mass eruption. It is concluded that these effects in the dynamics of coronal holes are an indication of the fact that a coronal mass eruption has occurred. It is shown that events with a clearly defined effect in the CH dynamics are attended with the strongest magnetic storms. For 80% of such events the storm amplitude $maxKp > 5$, and the mean value of the storm intensity $(meanmaxK_p) = 7^o$.

OBSERVATIONAL SUPPORT FOR 'VELOCITY REDISTRIBUTION' OF HE II IONS

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In a companion presentation (Jordan, Andretta & Garcia) we present evidence for a lower limit on the small-scale nonthermal velocity of He II ions, sufficient to produce an intensity enhancement that reproduces observations of the line in the quiet Sun. Here, we give examples of observations from a SOHO/ground-based, quiet-Sun campaign of May 8-13, 1997 that bear on this problem. These include observations of the 304 Å line made with the Normal Incidence Spectrometer (NIS) of the Coronal Diagnostic Spectrometer (CDS) on SOHO, and the +0.5 Å wing of the Hα line observed at the Coimbra Observatory. Correlations of common features in the coregistered images are discussed in an effort to identify similar regions of relatively large small-scale velocity in the chromosphere underlying where the 304 line intensity is enhanced.

GROUND-BASED AND SPACE-BASED MULTI-INSTRUMENT OBSERVATIONS OF THE DISPARITION BRUSQUE AND CME ACTIVITY OF 25/26 SEPTEMBER 1996

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A filament disparition brusque (DB) associated with a Coronal Mass Ejection (CME) was observed during a campaign of multi-wavelength observations with the SOHO (SUMER, CDS, EIT, MDI, LASCO) and the Yohkoh (SXT) spacecrafts, the MSDP multichannel imaging spectrograph, the MLSO/HAO Chromospheric Helium Imaging Photometer and the Nobeyama radioheliograph. The timeline of this complex event shows that a swelling of the corona had started before the DB of the filament. The DB was followed by a "ragged front" CME, while the main "bubble" of the CME was probably launched hours after the DB from the "zipper" region along the polar crown where an X-ray arcade formation was observed. We suggest that both the DB and the CME were symptoms of a general reorganization of large-scale fields on the Sun.

RAMAN SCATTERING EMISSION LINE IN THE SOLAR RADIATION SPECTRUM AS A NEW TOOL FOR INVESTIGATING THE SUN

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The optical spectra of many nonstationary stars reveal the emission lines H, He formed in their expanding atmospheres. The spectra of such nonstationary stars as symbiotic ones are, often have the wide (up to 20Å) emission line of about λ6825Å that has been identified comparatively recently as to be due to the Raman scattering of the OVI resonance line λ1032Å by the neutral hydrogen atoms (Schmid, 1989. AA.v.211.L31). Taking into consideration the presence of strong emission lines of OVI λ1032Å and the neutral hydrogen λ1216Å in the UV Sun's spectrum an attempt was made to reveal the Raman scattering in the visual range, namely, in the neighbourhood of λ6825Å. For this purpose the high-accuracy spectral measurements of the Sun-as-a-star, its centre and the sunspot umbra were used. Well-defined variations of the continuum level with the profiles typical for the emission lines were revealed in this spectral range on the background of the narrow Fraunhofer lines. Given proper procedure of determining the the parameters (profile, intensity, width and polarization) of this emission line it might be a new tool in the ground-based studying the transition region and the corona of the Sun in support of the spaceborne observations in line OVI λ1032Å like SOHO observations are.

QUIET SUN TRANSIENT ACTIVITY: BLINKERS, EXPLOSIVE EVENTS AND THE MAGNETIC CARPET

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Recent campaigns with multiwavelength observations of the quiet Sun have revealed some new features of transient solar activity. The extreme ultraviolet observations of the quiet Sun network in the few thousand K region, using the SOHO Coronal Diagnostic Spectrometer (CDS) have shown evidence for transient 'flashes' which have become known as blinkers. In addition, the magentic observations from the Michelson Doppler Imager (MDI) instrument also on SOHO have displayed a fine-scale magnetic 'carpet' with clear evidence for magnetic flux emergence and migration across cell structures. Are the CDS blinker events related to the merging of magnetic flux at the boundaries of the cells? Is there any relationship between the blinker events and the so-called 'explosive events' seen at longer wavelengths by the SOHO Solar UV Measurement of Emitted Radiation (SUMER) instrument, in the quiet Sun? These activities are globally distributed and it is quite possible that they may play a significant role in such global anomalies as coronal heating and solar wind acceleration. Thus, it is extremely important to clarify the nature of the phenomena seen in the quiet Sun by the SOHO instrumentation and to assess their significance to basic solar processes.

FOUR WAVELENGTHS 3D GEOMETRY OF SOLAR STRUCURES

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The four wavelengths images of the solar disk and corona from the EIT (Extreme ultraviolet Imaging Telescope) on board the precisely oriented Solar and Heliospheric Observatory (SOHO) have good astrometric properties. Their global stability and distorsion is better than 0"3. Pairs of the observed solar hemisphere at different times separated by 2 hours up to 10hrs are presented as pseudo stereo pairs. Analog points are visually located and further numerically processed in order to reconstruct the 3D geometry of hypothetically stable solar structures.
In this way we investigate static departures from perfect sphericity for structures, especially before and after events like coronal mass ejections, flares, and *disparitions brusques*.
We then speculate about actual dynamic stereo viewing of the Sun by simultaneaous observations from widely separated points.

OBSERVATIONS OF AN ERUPTING PROMINENCE

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A prominence eruption, small flare and coronal mass ejection were seen on April 9th 1997 on the SW limb of the Sun. Images of the events taken in Fe XII line with EIT, the Fe XIV line with LASCO C1 and C2 coronagraphs, the YOHKOH soft X-ray telescope, and Hα show the relationship between the different phenomena. The CDS obtained spectra of the ejected filament in O III, O V and Mg IX as it raced outward through the corona as well as images before and after the main events in lines ranging from cool He I emission to hot Fe XVI emission.
The presentation will be accompanied by a video.

CORRELATIVE STUDY OF CORONAL AND TRANSITION REGION EMISSION PATTERNS WITH THE MAGNETIC FIELD STRUCTURE USING SOHO OBSERVATIONS

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A long-term scan of 17 hours of a solar active region was performed by the SUMER instrument on November 17, 1996, another scan of 10 hours was performed on November 20, 1996. While the spectrograph slit was held fixed at the central meridian, the rotation of the Sun permitted the mapping of the line emissions of the transition region lines (e.g., N IV at 765 Å) and a low coronal line (Ne VIII at 770 Å) over a region of 106 arcsec in latitude and 163 arcsec in longitude. On the second day, transition region lines (Si IV, S IV, O IV around 1400 Å) were observed over a region of 80 arcsec in latitude and 111 arcsec in longitude. The organization of the dynamical parameters in terms of upward and downward flows will be compared with the magnetic field structures measured by MDI.

A LOWER LIMIT ON NONTHERMAL VELOCITIES OF QUIET-SUN HE II IONS

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A critical parameter in determining the formation of the He II 304 Å line in the Sun is the magnitude of the nonthermal velocity of these ions. Earlier work has strongly suggested that the dominant formation mechanism in the quiet Sun is likely to be electron collisional excitation of these ions, but a means of enhancing the theoretical intensity to agree with observations is still sought. An earlier proposal to achieve this was mixing of the ions with 'hotter' thermal electrons by what we call 'velocity redistribution.' Evidence from SERTS sounding rocket observations has established the probability of sufficiently high velocities of these ions. Here we demonstrate an observationally determined lower limit on the small-scale nonthermal velocity of the He II ions in the quiet Sun. This lower limit is large enough for velocity redistribution to yield the line intensities observed there. In a companion presentation (Garcia, Jordan, Brosius & Andretta) we present and evaluate some relevant SOHO and ground-based observations to further test the velocity redistribution hypothesis.

STUDIES OF HELIUM LINE FORMATION IN THE SOLAR TRANSITION REGION BASED ON SOHO JOP 62.

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Previous studies (Jordan 1975, 1980) have found that the resonance lines of He I and He II appear to have higher fluxes than expected from models made using other transition region lines formed at similar temperatures. The enhancement factor was shown to be less in coronal holes than in the quiet Sun. These results referred to observations made with low spatial resolution. Using the higher spatial resolution provided by the CDS instrument, initial results confirming the anomalously high helium line fluxes have been reported (Macpherson & Jordan 1997). SOHO Joint Observing Proposal 62 was devised to study the helium problem in greater detail and has been implemented for several repeat runs. It involves simultaneous CDS, SUMER, EIT and MDI observations. Using SUMER observations to derive transition region electron densities in tandem with CDS observations of He I, He II and other line fluxes, we model the emitting regions and investigate the systematic behaviour of the Helium lines. MDI magnetogram data is used to correlate the magnetic field with the helium enhancement factors. Results of these investigations will be reported.

ABSORPTION OF γ-RAYS AND DIAGNOSIS OF SOLAR PLASMA DENSITY ALTITUDE PROFILE FROM THE TIME DEPENDENCE OF SOLAR FLARE γ-LINE

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In our previous papers we have shown, that the time history of neutron capture by hydrogen 2.2 MeV γ-line from the solar flare contains the information about the altitude profile of the solar plasma density. We have proposed a method for determining the altitude dependence of the density of solar plasma, particularly, in the deep photosperical and subphotospherical layers, which are inaccessible for optical observations, from the time profile of γ-ray emission at 2.2 MeV. But the absorption of γ-rays must put limitations to this method. So we make allowance now for the absorption of γ-rays, and we present the results of our calculations.

POLAR PLUMES AND FINE-SCALE CORONAL STRUCTURES - ON THE INTERPRETATION OF CORONAL RADIO SOUNDING DATA

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Variations in total electron content at high heliographic latitudes, observed during the 1995 solar conjunction of the Ulysses spacecraft were interpreted by Woo and Habbal [1997b] as polar plume structures extending to at least 30 solar radii from the Sun. Surprisingly, we detected a 24-hour sinusoidal oscillation of the total electron content with a peak-to-valley amplitude of about 10%, most probably caused by a ground station calibration error. Model calculations were performed under the assumption that these electron content variations are indeed the signature of plumes moving in and out of the radio ray path. If the density contrast between plume and interplume regions is low, then the plume structure must occupy a significant fraction of the radio ray path. If the plume extent along the line-of-sight is of 2.5°, as taken from SOHO coronagraph data, then the density contrast is quite high (factor 8 or higher). Neither scenario seems reasonable under the given geometry.

VLA AND SOHO OBSERVATIONS OF SOLAR ACTIVITY

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We present simultaneous observations of solar active regions with the SOHO spacecraft (CDS and EIT at EUV wavelengths) and the Very Large Array (VLA at 3.5, 6.2, 20.7 and 91.6 cm wavelength). The VLA data provide unique information on nonthermal electron populations, signatures of magnetic reconnection, and coronal magnetic field strengths. The spatial and temporal relationship of transient events in the EUV and radio domains are presented. We determine radiation mechanisms and constrain physical parameters, such as the electron temperature, electron density and magnetic field strength, of the emitting regions. Changes in long-wavelength radio brightness are related to some EUV ejection events, suggesting an interaction, at different levels in the solar atmosphere, between large-scale magnetic loops with nonthermal electrons and small-scale erupting loops. Some EUV transient events, lasting minutes to tens of minutes, are spatially and temporally coincident with radio emission that is attributed to nonthermal electrons in regions of high magnetic field strength near sunspots. The coronal magnetic field strengths above sunspots are about 75% of those in the underlying photosphere. Other EUV events have no detectable radio counterpart

COLLISIONLESS 3D RECONNECTION IN THE SOLAR ATMOSPHERE RELATED TO ERUPTIONS

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Some new results concerning the observations and study of magnetic reconnection in the solar corona are reviewed. The collisionless 3D reconnection theory – more exactly, the model of a high-temperature turbulent-current non-neutral current sheet – is applied to the coronal conditions derived from multi-wavelength observations. New theoretical interpretations are discussed of the *Yohkoh* and correlated multi-wavelength data on the site and mechanism of magnetic energy transformation into kinetic and thermal energies of superhot plasmas and accelerated high-energy particles. Open issues are the focus of our attention.

THE TEMPORAL AND ENERGETIC PARAMETERS OF X-RAY SOLAR FLARES OF DIFFERENT CLASSES

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Using the data of the direct measurements of the X-ray radiation flux from the solar flares ($1 - 8\AA$, GEOS) the basic temporal and energetic parameters of solar flares of different classes were calculated over the period 1977-1996. All these parameters reveal the dependence on the phase of the 11-year cycle.
The estimated combined flare energies released in each complete cycle coincide to 10% accuracy.
The energetics of the flares of the high-power groups corresponding to the E-F balls in the optical range has been studied. It has been found that the index of the integrated spectrum varies within the solar cycle both for the whole Sun and high-power sunspot groups. It counts in favour of the suggestion that the global solar features also varied within the cycle affect the flare initiation. This conclusion should be refined using all lower-power sunspot groups, nevertheless, it tentatively provides insight into the theory of flare initiation.

THREE DIMENSIONAL MAGNETIC RECONNECTION IN A LIGHT OF XUV LINES ANALYSIS

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In highly complex fields of the solar corona magnetic reconnection can take place in 3D (three-dimensional) current surfaces. 3D reconnection was considered in a number of theoretical papers. However, it is not studied in such details as reconnection in plane sheets. We use an analysis of XUV lines to investigate magnetic reconnection in 3D current surfaces. We find that a main spectroscopic effect of such reconnection is that it gives rise to a non-symmetrical broadening in lines. In contrast to it, a broadening associated with reconnection in plane sheets is symmetrical. From the other side, to differ the '3D induced' broadening from a non-symmetrical broadening determined by a chromospheric evaporation we have to study the initial stages of flare-like events, before an appearance of secondary effects (such as the evaporation etc.). Using a statistical analysis we determine a ratio of reconnection events taking place in 3D surfaces to events in plane current sheets. We find physical processes and conditions (an emerging flax, a singular field line in the corona etc) at that reconnection realizes through 3D surfaces or through plane sheets respectively. We study differences in energetics of these two types of magnetic reconnection, the spatial and temperature fine structures of related parts of the solar atmosphere. For the investigation in EUV, SoHO data are extremely valuable. SMM and Yohkoh data are appropriate for the research in the soft X-ray.

COMPARISON OF OUTFLOW VELOCITY DETERMINATIONS WITH UVCS AND LASCO FOR THE CORONAL MASS EJECTION OF 13-14 AUG 1997

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The Ultraviolet Coronagraph Spectrometer (UVCS) on SOHO was used to observe a Coronal Mass Ejection (CME) on 13-14 August 1997. The event was observed simultaneously with the LASCO white light coronagraph. This paper describes the first results from a comparison of outflow velocities determined from UVCS Doppler dimming studies with the velocities determined by examining the proper motions of the CME as measured by LASCO. Strengths and weaknesses of the various outflow determinations will be discussed.

LINE PROFILES ACROSS THE SOLAR LIMB OBSERVED WITH SUMER

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We present high resolution spectral data from the SUMER instrument on SOHO, obtained on 20th March 1997, during which two spacecraft rolls of SOHO were performed. A first roll covered one full rotation, dwelling approximately 30 minutes at angular intervals of 30 degrees. The 1×300 arcsecond^2 slit of SUMER was centered 70 arcseconds inside the limb. A second roll dwelled longer at fewer roll angles, and the SUMER slit was moved to cover an entire solar radius, from limb to disk center. Data were acquired during both rolls in selected wavelength bands between 760 and 1410 Å, including emission lines formed from the chromosphere to corona.
The line profile data contain information on the poorly known center to limb variation of the pervasive redshift observed in transition region lines. These data are therefore vital to determine the viability of models of the solar upper atmosphere, in particular of the transition region. We present line profiles of lines formed in the chromosphere, transition region and corona, and discuss their impact on models of the solar transition region.

CO-ORDINATED OBSERVATIONS OF LARGE SCALE CORONAL BRIGHTENING AND Hα SURGE

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Abstract: An eruptive two-ribbon flare(2N/M2.6) occurred on February 4, 1995 in the active region NOAA7834. During the post-flare phase, with the Soft X-ray Telescope(SXT) on board Yohkoh, we observed the rapid brightening of a set of large scale coronal loops(100-150Mm in length). One common foot of the parellel loops was located in the previous flaring region, and the other foot at a remote site of inversed magnetic polarity. Simultaneously, co-ordinated ground-based observations from Sacramento Peak and Solar Optical Observing Net(SOON) reveal a co-incident Hα surge event. The ejection of the cool chromospheric materials originated from the previous flare region and went along different branches of the large coronal loops. To our knowledge, the Hα surge event co-incident with the large scale coronal brightening observed by Yohkoh has not been reported.
The possible mechanisms for the concurrent cool plasma ejection and the filling of the hot coronal loops are discussed. We find it most convincing that magneticreconnection between a magnetic arcade and an overlying large scale coronal structure accounted for the co-incident events. The thermal conduction front and the slow shock resulting from the reconnection could heat the coronal plasma to the temperature of 10MK.

ST14 Solar imprints in terrestrial archives (joint with OA)

Convener: Cini-Castagnoli, G.

RESULTS OF CYCLOGRAM ANALYSIS OF EL NIÑO OCCURRENCES TO SEARCH FOR POSSIBLE PHASE RELATIONSHIP WITH SOLAR ACTIVITY

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The cyclogram analysis has been applied to the dates of El Niño occurrences as reported by Quinn et al.(W.H. Quinn. V.T. Neal, S.E. Antunez De Maiolo. El Niño Occurrences Over the Past Four and a Half Centuries. J.G.R.. 92. 14449-14461. 1987). The results will be discussed. This new kind of analysis can detect possible phase relationships of El Niño occurrences and a possible relationships with solar activity cycles or some other geophysical oscillating phenomena, including possible phase locking among them.

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Effect of the secular variations of earth's axis inclination.earth's orbit eccentricity and vernal equinox anomaly on latitude distribution of solar radiation mean intensity is investigated. Different combinations of these parameters change shapes of phase trajectories of annual latitude movement of maximum insolation mean intensity.These trajectories being distributed between the Tropic of Cancer and the Tropic of Capricorn are degenerated into the lines during glacial and heating periods.

THE BASIC 180-YR AND 2200-YR CYCLES IN THE SOLAR MOTION

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On the time interval long 9000 years, the 2200-yr modulation of the basic 180-yr period of solar inertial motion will be demonstrated. (The Sun returns on the trefoil orbital type always after 179 years. In the intermediate intervals, the Sun moves along different chaotic orbital patterns and these intervals coincide with the known prolonged minima of solar activity, such as the Sporer, Maunder, Dalton, etc. minima.) The 2200-years modulation has been detected in two ways: the first consists in a repetition of the intervals long about 400 years, where the Sun exceptionally moves along the trefoil orbital pattern. The second follows from the coincidence between the Sporer and Maunder orbital patterns and the respective Sporer and Maunder types of prolonged minima of solar activity. The trefoil orbit is a repeating, exceptional and stable pattern in solar motion. The same properties of the solar-terrestrial phenomena have been found there. The solar motion, separated into two basic orbital types, could serve as a basis against which solar imprints in terrestrial archives could be related.

RECONSTRUCTION OF THE SOLAR ACTIVITY BASED ON THE ANALYSIS OF COSMOGENIC RADIONUCLIDES IN ICE CORES

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Solar activity modulates the flux of the galactic cosmic rays through magnetic fields carried by the solar wind. This modulation effect has been calculated as a function of geomagnetic latitude and solar activity using Monte Carlo simulations of the interaction between cosmic ray particles with the atmosphere. Records of cosmogenic radionuclides measured in ice cores allow to derive the corresponding modulation factor and to reconstruct the history of solar activity over the last several centuries.

SOLAR VARIABILITY IMPRINTED IN THE $\delta^{18}O$ TIME SERIES OF A SHALLOW WATER MEDITERRANEAN CORE

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The $\delta^{18}O$ profile *of Globigerinoides Ruber* was measured in a shallow water core of the Ionian sea over the period 1200 - 1900 A.D., with the fine resolution of 3.87 years. An accurate dating of the core has been performed by ^{210}Pb radiometric method and by a detailed tephroanalysis. The markers of the historical volcanic eruptions which occurred in the Campanian area (Vesuvius, Phlegrean Fields, Ischia) during the last two millennia have been identified along the cores. The high precision of the core dating allows to transform the depth scale into a time scale with an accuracy of ~1%. The analysis of several cores taken in the same area demonstrates that the results presented here are of general validity, at least in this region. The spectral analysis of the $\delta^{18}O$ time series with different methods show that the dominant periodicity corresponds to 11.4 years; in particular the Singular Spectrum Analysis (SSA) shows: a) the first two leading components (RC 1-2) of the record correspond to a deterministic signals with period 11.4 y in phase with the sunspot record and with an average amplitude of 0.08 per mil. The statistical significance is given by Monte Carlo SSA (MC-SSA). b) The trend (RC 3-4) shows a minimum (warm) in 1400 A.D. and maximum (cold) in 1700 A.D., corresponding to the well-known climatic feature of the Little Ice Age. c) The 22 y running mean of the sunspot record and of the $\delta^{18}O$ time series show the same behaviour from 1700 to 1850 A.D. From there on, the $\delta^{18}O$ time series records the temperature effect due to the CO_2 antropogenic increase.

INVESTIGATION OF THE REFILLING PROCESSES OF CONVECTED PLASMA TUBES ON THE BASIS OF HYDRODYNAMICAL MODEL OF PROTONOSPHERE IN 8-MOMENT APPROXIMATION

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The distributions of concentration Ni and temperature Ti of H+ ions in plasma tube, convected from polar cap to L=6,1 at night, dawn and day side, as well as to L=8,1 at dusk side are presented. They are obtained with help of simplified numerical model of protonosphere based on the set of quasi-hyd- rodynamical transport equations of H+ ions in 8-moment approximation. The integration of model equations is executed along dipole geomagnetic field lines between their bases selected on height of 3000 km. There is assumed, that geomagnetic field lines of polar caps are open. There is taken into ac- count that during magnetospheric convection of plasma tubes the change of their volumes happens. Parameters of steady-state polar wind are chosen as initial conditions for all tubes. The investigation of effects of plasma tube adiabatic compression and expansion in consequence of magnetospheric convection is performed. The distributions of Ni and Ti in meridional planes conformed to 00, 06, 12 and 18 MLT on various heights in protonosphere and in equatorial plane of magnetosphere are obtained. The heating of H+ ions (up to 100000 K) behind the plasmapause, qualitatively agreeing with observations of hot zone in plasmasphere is obtained. This heating is reproduced thanking to addition of the model set by ion heat flux equation.

EARTH'S CLOUD COVER AND COSMIC RAY FLUX VARIATIONS

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A recent result indicates that the Earth's cloud cover, observed by satellites, is strongly correlated with the cosmic ray flux, which in turn is inversely correlated with the solar activity[1]. Since clouds are very important in the radiation budget of the Earth, an influence via cosmic ray flux will have significant climatic effects. For example during the last solar cycle the total cloud cover varied with approximately 3 - 4 % which could correspond to a variation of 1.5 Wm^{-2} during this period. In the talk we will present results on the variations of cosmic ray flux and cloud types and show spatial correlation patterns. An estimate of the importance of different solar activity parameters like, solar radiation, ultra-violet radiation, X-ray radiation, 10.7 cm solar flux, and cosmic ray flux, will be made on the basis of observations of surface temperature on time scales ranging from years to centuries. The results could provide a explanation of the correlation between solar cycle length and global temperature.

[1] H. Svensmark and E. Friis-Christensen, J. atm. sol.-terr. Phys., 59, 1225 (1997)

SOLAR WIND VARIATIONS AND TERRESTRIAL RESPONSES

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The solar wind intensity varies with the sunspot activity. It is well recorded that this modulates the Earth's geomagnetic shielding so that the infall of cosmic ray varies, by that affecting the formation of atmospheric ^{14}C. At the same time it seems to affect the Earth's rate of rotation. During the periods of low sunspot numbers – the Spörer, Maunder and Dalton minima – Earth's rate of rotation increased. This affected the oceanic circulation so that the a major current like the Gulf Stream sent less warm equatorial water along its northern branch towards NW Europe at the same time as Arctic water penetrated furter south. This led to severe cold periods – known as Littele Ice Ages – in the NW European region. In southern Europe and northern Africa the same periods were characterized by increased heat. This means that these periods represent changed distribution of the terrestrial energy. And this was driven by increased rate of rotation. In this scenario, we do not need to call for hypothetical large-scale variations in solar irradiance; only an influence of the solar wind variability on Earth's rate of rotation. There are physical means of understanding the linkage between solar wind intensity and Earth's rotation.

ST15 Atmospheric ozone (co-sponsored by OA)

Convener: Hirschberg, M.-M.

01 Modelling and validation with satellite data

Convener: Vardavas, I.M.
Co-Convener: Taylor, F.W.

Measurement of middle atmospheric trace gases from the Sub-Millimeter Radiometer instrument aboard the Odin satellite.

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The Odin satellite is a common project to Sweden, France, Canada and Finland, with the main characteristics to observe alternatively the middle atmosphere and astrophysical sources. Two instruments will be operated onboard : the Sub-Millimeter Radiometer (SMR) consists of five microwave radiometers in millimeter and sub-millimeter wavelength ranges and an Optical Spectrograph and Infrared Imaging System (OSIRIS) will operate in uv-visible and infrared wavelength ranges. The launch is foreseen in October 1998. The atmospheric limb will be scanned from 10 to 100 km. The sub-millimeter emission lines of trace gases will be measured at frequencies ranging from 480 to 580 GHz. We present the Odin mission and the sub-millimeter retrieval algorithm based on the Optimal Estimation Method. The characterisation of the errors and their impacts onto the retrieved profiles are also discussed. Retrieval budgets for O_3, ClO, H_2O, HNO_3 are finally shown.

THE MSDOL PROJECT: ASSIMILATION OF GOMOS OZONE DATA IN A 3-D CHEMISTRY-TRANSPORT MODEL

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In the frame of the preparation of the use of ENVISAT data, the Environment and Climate Programme of the EEC is supporting the MSDOL project: Monitoring of the Stratospheric Depletion of the Ozone Layer. The purpose is to assimilate the 400 vertical profiles of Ozone recorded each day by the experiment GOMOS in a 3-D chemistry-transport model, where the winds are derived from the ECMWF analysis for the lower part of the stratosphere. The sequentially assimilated model will better represent the reality since all single measurements are extrapolated in time through chemistry and transport. The assimilated model will serve at least two purpose : the comparison with other data sets, and the estimate of the evolution of ozone as a function of time and space.
The 3-D model is derived from the stratospheric chemistry-transport Rose model, in which the internally generated dynamics is replaced by the actual wind field. The first results with simulated GOMOS data will be presented.

INVERSION OF OZONE PROFILES FROM HIGH RESOLUTION IASI SPECTRA.

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The method used to extract ozone profile is based on the minimization of observed and calculated spectra in the 9.6 micron ozone band. The aim of the inversion is to estimate the profiles' accuracy and height resolution achievable with IASI spectra. Synthetic spectra calculated with the 4A-93 line by line model and transformed by the instrumental transfer function are used as observations. Inversions in tropical and mid-latitude conditions provide relative accuracies of 10% over a set of nine layers.

Stratosphere-Troposphere exchange: case studies recorded at Mt.Cimone during VOTALP project

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In order to point out and study the stratospheric/upper tropospheric transport of ozone rich air masses in the lower troposphere, continuous measurements of several parameters are undertaken at four mountain peaks, Jungfraujoch, Sonnblick, Zugspitze and Mt.Cimone during the European Community VOTALP project (Vertical Ozone Transports in the Alps).
Several high values of surface ozone concentration due to vertical stratospheric-tropospheric exchange have been recorded in these mountain peak stations. This work presents and analyses data concerning the Mt.Cimone ground-based station, which is the highest peak of the Italian Northern Apennines and the most representative WMO-GAW site in Italy.
Episodes of vertical exchange in the lower stratosphere, as tropopause folding, or in the upper troposphere, as down draft transport, have been recorded at Mt.Cimone since march 1996 and subsequently studied. In fact the comparison between the trends of different background trace gases at a mountain baseline station, the weather situations and the backward trajectory analyses can bring to light these events and can be very useful for a better knowledge of transport phenomena.
Correlation between high level of ozone concentration, chemical and meteorological parameters and three-dimensional backward trajectories relative to same events are shown.

OZONE VERTICAL DISTRIBUTIONS FROM GOME/ERS-2 SATELLITE DATA - II: OBSERVATIONS IN THE ARCTIC WINTERS 1996/97 AND 97/98

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The discovery of the Antarctic ozone hole in 1985 led to much scientific and public debate. A similar O3 loss above the Arctic was initially considered less likely because of the different dynamics of the Arctic polar vortex.
The retrieval program FURM, developed at the Institute of Remote Sensing in Bremen, is used to derive vertical ozone profiles from GOME satellite data on a near-global scale. Observations of the ozone content in different layers of the atmosphere for the Northern hemisphere during the Arctic winters 1996/97 and 1997/98 will be presented and discussed. By correlating the ozone distribution to meteorological parameters and to the distribution of other trace gases it is possible to attribute ozone variations to dynamical and/or chemical causes. The measurements of winter 96/97 seem to indicate that processes similar to those leading to the Antarctic ozone hole can take place in the Arctic.

EFFECT OF HOBR ON CATALYTIC DESTRUCTION OF OZONE IN THE LOWER STRATOSPHERE OF MIDLATITUDES, MODEL STUDIES INITIALIZED WITH UARS/HALOE DATA

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A photochemical box model on trajectories initialized with UARS/HALOE data for ozone and key species setting constraints to its catalytic destruction cycles is used to look for the sensitivity of ozone net destruction rates to the photolysis of HOBr including heterogeneous chemistry. Here we use the faster photolysis rates recently measured in our laboratory and compare that with older recommendations and a case where HOBr is neglected at all. It is demonstrated that especially in case of large sulfate aerosol surface density (Pinatubo) the effect of bromine induced reduced NOx and enhanced HOx significantly increases the net ozone destruction rates. Examples will be given for different years from 1992 to 1997 with focus on midlatitude summer. Preference is given to cases where the forward trajectories match the locations of other HALOE observations for validation.

TROPOSPHERIC OZONE AND ITS PRECURSORS: IMG MEASUREMENTS AND ATMOSPHERIC MODELS

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Global scale measurements of infrared absorbing trace gases were performed by the IMG remote sensor, which was launched onboard the ADEOS platform in August 96 and stopped operating after 10 months. IMG uses a Fourier transform interferometer to record the terrestrial thermal infrared radiation and provides atmospheric spectra from which O_3, CO and CH_4 may be measured. The nadir-viewing mode of the instrument allows to retrieve total column amounts each 86 km along the track of the satellite.

These measurements have been compared to the results provided by the three-dimensional chemistry-transport models IMAGES and MOZART. The differences between measurements and models have been analyzed for O_3 and its main precursors CO and CH_4, and the possible sources of discrepancies will be discussed.

CALCULATING THE FUTURE DEVELOPMENT OF THE OZONE LAYER WITH A DYNAMIC-CHEMICAL GCM

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The coupled dynamic-chemical general circulation model ECHAM3/CHEM is employed to estimate the possible future development of the stratospheric ozone layer. For the year 2015, the adopted increase of greenhouse gas concentrations and the corresponding modification of the sea-surface temperature lead to a warming of the troposphere and a cooling of the stratosphere. Considering the decrease of chlorofluorocarbons in the model atmosphere, which follows the agreement of Copenhagen (1992), the assessment for the year 2015 indicates that the ozone layer will not homogeneously recover. Whereas in low and mid-latitudes an enhancement of ozone mixing ratios is obvious, no significant increase of stratospheric ozone is found in the polar regions during spring time, especially over the Antarctic.

THE VISUALIZATION AND VALIDATION OF GOME (ERS-2) TOTAL OZONE MEASUREMENTS USING GIS TECHNOLOGY

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A comparison of limited set of ground-based (ozonometer M - 124) and satellite (GOME instrumentation, ERS-2) total ozone measurements over the northern-west and central regions of Russia in July and September-October of 1996 was accomplished. Satellite measurements systematically underestimate the total ozone in comparison with ground-based measurements, on the average, by 17 - 34 DU, depending on the comparison conditions. Permanent control of the quality of total ozone measurements testify to a lack of systematical measurement scale shift at the north-western Russian stations. Therefore it should be concluded that there is a systematical scale shift of the GOME total ozone measurements.

MODELED OZONE TRENDS

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A two-dimensional dynamical radiation-photochemical model of the troposphere and the stratosphere that embraces aerosol physics is used to examine the changes of ozone layer of the Earth occurring during the last 20 years. These changes are caused by anthropogenic atmospheric pollution, solar cycle variations of UV radiation flux, and sulfate aerosols from volcanic eruptions and regular flights of commercial aircraft. We show that the resulting effects of all the above factors is a negative ozone trend in the entire stratosphere. This trend is most significant in winter in the polar Northern and Southern areas. For example, for the $50°N - 60°N$ region at $45km$ altitude, the ozone trend is about -8% to -9% per decade. This trend fairly agrees with the ozone trend observed with SBUV and SBUV/2. The model values for the global annual average of total ozone (GAATO) computed for the range between $65°S$ and $65°N$ are in the good agreement with the experimental GAATO data obtained with TOMS during the period of 1979 through 1994. We show that the GAATO trend caused by anthropogenic atmospheric pollution is about -2.8% per decade. The solar UV flux variations in the course of the 11 year solar cycle contribute $\pm 0.6\%$ in maximums (about 1.2% from the solar maximum to the minimum of the cycle). The sulfate aerosol increase as a result of the El Chichon and Mount Pinatubo eruptions leads to the local GAATO changes in 1983 and 1992 about -1.6% and -2.7%, respectively.

SIMULATION OF THE ATMOSPHERIC OZONE DISTRIBUTIONS WITH THE 2-D MODEL AND VALIDTIONS WITH HALOE AND TOMS DATA

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A two dimensional model of radiative, dynamical and photochemical processes in the stratosphere has been developed and used for study of the atmospheric ozone distributions. The model calculates stratospheric wind velocity components, air temperature and humidity; short- and long wave radiation fluxes, chemical species source-sink intensities and concentrations. Temperature, humidity and circulation in the troposphere are prescribed and taken from observations. Chemistry module calculates 38 species concentrations. The 16 long lived gases are transported. The fully implicit Newton-Raphson method is used for 22 short lived species. The heterogeneous reactions in/on sulfate and PSC particles are taken into account. The results of numerical simulations are compared with the HALOE measurements and the TOMS data. The comparison of the simulated and the HALOE stratospheric O_3 data has been made in tropical, mid, and high latitudes for all seasons. It shows that the overall agreement between model and measured fields is within 5-15% for almost whole stratosphere except the high latitudes of the winter hemisphere. This disagreement is a common problem for all 2-D models, which can not reproduce the planetary and gravity wave breaking processes over the high latitudes. The comparison of the simulated total ozone and TOMS data also will be presented.

LIGHTNING PRODUCTION OF NO_x AND ATMOSPHERIC OZONE

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For tropospheric chemistry lightning is a major source of NOx. NOx in turn affects the concentration of ozone in the atmosphere, which is an important greenhouse gas. In this study we estimated lightning production of NOx and its influence on distribution atmospheric ozone in the upper troposphere and the low stratosphere depends on global source strength. A two dimensional model of radiative, dynamical and photochemical processes in the stratosphere has been developed and used for. The transformations of 38 species are calculated in the chemical part of the model with Newton-Rafson scheme. About 100 gas-phase and 5 heterogeneous reactions on sulfate and PSC particles are included in the model. We compare NOx and NOy simulated by our 2-D model with available observations to choose suitable global lightning source of NOx. NOx produced by lightning flashes are distributed by latitude, altitude and season variations. Having generated our two-dimensional, time-dependent relative distribution of NOx emissions by lightning, we have made preliminary experiments with different total source of NOx (2-20Tg/year). It shows that concentrations of NOy and O_3 almost independent on global source strength of NOx in the stratosphere, but very important for upper troposphere.

APPLICATION OF MONTE CARLO SIMULATION OF MULTI SCATTERING RADIATION TRANSFEREE TO ERROR ANALYSIS OF EXTENDED BREWER UMKEHR METHOD FOR OZONE PROFILE DETERMINATION

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Umkehr method is applied at network of Brewer spectrophotometers to determinate the ozone vertical distribution. To improve its accuracy opportunities, an extended Brewer Umkehr method was proposed by authors. Two ways to employ multiscattering radiation transferee model in the retrieval algorithm of the extended Umkehr method are investigated. Both use the Monte Carlo numerical method of radiative transferee simulation. We applied the double local estimation method with physical sampling of the free path length without escape until two collisions occurred and take into account spherical geometry and polarization properties. The main deductions on the method accuracy are defined more exactly in comparison with single scattering modeling. Some new features are displayed in the lowest stratosphere.

VARIATIONAL ASSIMILATION OF OZONE TOTAL COLUMN SATELLITE DATA IN A 2D LAT-LON TRACER-TRANSPORT MODEL

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A 4D variational data assimilation method is described to derive global ozone distributions from total column ozone satellite measurements. The ozone columns are advected by a 2D tracer transport model, using ECMWF wind fields at a single pressure level. Special attention is paid to the modelling of the background error covariance and quality control. The time, latitude and season dependence of the forecast error are taken into account, resulting in a global error field at any instant in time that provides a local estimate of the accuracy of the assimilated field. We discuss the advantages of the variational approach over sequential assimilation schemes. One of the attractive features of the variational technique is its ability to incorporate measurements at later times $t > t_0$ in the analysis at time t_0. In this sense twice as much information is extracted from the sparse measurements.

APPROXIMATE LIMB SOUNDING DATA INVERSION.

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The new effective approximate technique is presented. The mathematical basis of it is the asymptotic expansions techniques and Laplace integrals. Unknown atmospheric gas distribution is rough approximated by exponential function $f(r,\varphi)\exp(-\lambda r)$. Integral over a ray trajectory with the tangent point coordinates (p,φ) known from the limb occultation experiment is $I(p,\varphi) = \int f(r(x),\varphi(x))\exp(-\lambda r(x))\,dx$ where x is the local Cartesian coordinate along the trajectory. Using the Laplace integral asymptotic expansion we get approximate equation which can be used to retrieve unknown function $f(r,\varphi)$:

$$I(p,\varphi) \approx \exp(-\lambda p)\left\{\sqrt{\frac{2\pi p}{\lambda}} f + \frac{3}{8\lambda}\sqrt{\frac{2\pi}{\lambda p}} f + \frac{1}{\lambda}\sqrt{\frac{\pi p}{2\lambda}}\frac{\partial f}{\partial r} + \frac{1}{\lambda}\sqrt{\frac{\pi}{2\lambda p}}\frac{\partial^2 f}{\partial \varphi^2} + O\left(\lambda^{-3/2}\right)\right\}.$$

This approach has several advantages. It's regular, because the solution of this differential equation continuously depends on left-hand side and any additional information can be integrated into retrieval scheme through boundary and other conditions for the unknown function. Application of this technique to occultation measurements of different physical effects, such as refraction, microwave phase shift, absorption, airglow emission, refractional attenuation etc. are discussed. The results of the numerical simulation are presented. Application to the local spherical symmetry approximation (LSSA) results correction is also included in the report.

ANNUAL VARIATION OF THE STATISTICAL LINK BETWEEN ZONALLY ASYMMETRIC TOTAL OZONE TREND AND DECADAL CHANGE IN DYNAMICS

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At the example of March it will be shown that upper tropospheric and lower stratospheric decadal change of dynamics during 1979 - 1992 distinctly influences the spatial distribution of zonally asymmetric (longitude dependent) decadal ozone change in mean latitudes of the northern hemisphere. These influences will be shown by spatial correlation of total ozone measurements from TOMS on board of Nimbus 7 and of Adeos together with NCEP geopotential height change of 300 hPa, found as a good indicator of dynamics in the called height region. The spatial regression between decadal ozone change and geopotential change is - 0.16 (DU/yr)/(gpm/yr), and is significant with more than 99 %. This diagnostic analysis is extended to all month of the year. In the annual variation these values vary between - 0.17 in spring and - 0.07 (DU/yr)/(gpm/yr) in autumn, in similarity to the annual variation of total ozone density, whereas the spatial correlation between decadal ozone change and geopotential height change is high in summer and relatively low (but still significant) in winter in similarity to the annual variation of the variability of dynamics.

3-D global simulations of tropospheric O3 budget - results of the GIM/IGAC intercomparison 1997 exercise.

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The objective of the Tropospheric Ozone (O3) Global Model Intercomparison Exercise performed in 1997 was to systematically evaluate the capabilities of the current generation of 3-dimensional global models used for tropospheric O3 studies, and to identify key areas of uncertainty in our understanding of the tropospheric O3 budget. This exercise has been organised by GIM (Global Integration Modelling) part of the IGAC (International Global Atmospheric Chemistry) activity. The strategy was to investigate the coherence of the models and how do the model results compare to the real atmosphere. 12 global 3-dimensional Chemistry Transport Models have been participated at this exercise. These models differ in the parametrisation of the main processes controlling chemical tracer budgets i.e. transport by advection, diffusion and convection, chemistry (homogeneous and heterogeneous), wet and dry deposition, and emission of trace compounds by natural and anthropogenic sources. On the basis of these results, the uncertainties in tropospheric O3 budget and the performances of the models will be discussed and the differences will be analysed.

LONG-TERM MONITORING OF STRATOSPHERIC OZONE AT THE OBSERVATOIRE DE HAUTE-PROVENCE USING GROUND-BASED AND SATELLITE INSTRUMENTS.

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A study of the long-term evolution of the stratospheric ozone at the Observatoire de Haute-Provence (43.9N, 5.7E) is performed using ground-based measurements from Dobson spectrophotometer, lidar, ozonesondes, and using SAGE II satellite measurements. Those experiments provide datasets with lengths of about 10 years, which allows the comparison of interannual variability of the ozone measured by the different instruments. A multi-parameter regression is used to extract the long-term evolution from other variations (seasonal variability, Quasi-Biennal Oscillation forcing) of total ozone and of vertical profiles from the different experiments between 1985 and 1995. The effects of volcanism and of the 11-year solar cycle on long-term evolution of ozone are studied too. Differences between the time series of the ozone residuals after the regression underline instrumental differences and possible instrumental sensitivity to the volcanic aerosols for some of them.

SIMULATIONS OF STRATOSPHERIC CONSTITUENTS IN A UNIFIED CLIMATE / FORECAST MODEL

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A high resolution three-dimensional general circulation model with stratospheric chemistry interacting with the model heating rates is integrated for a sequence of 10 day periods. The periods are chosen to coincide with low temperatures in the lower stratosphere when polar stratospheric clouds occurred. The initial conditions are taken from observations from the northern winters 1992-1998 and comparisons are made between simulations with different polar stratospheric cloud (PSC) schemes. Results are analysed, amongst other ways, in terms of the ozone change on the 475 K isentropic surface for air parcels within the vortex, as defined by equivalent latitude. The effects of the different PSC schemes and of the different time of year on the constituent concentrations are discussed.

ASSIMILATION OF THE UARS/MLS OZONE MEASUREMENTS IN A 3-D STRATOSPHERIC CHEMISTRY TRANSPORT MODEL

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A sequential data assimilation scheme has been implemented in the 3-D global stratospheric chemistry transport model ROSE (Rose and Brasseur, 1989). The model contains an extensive photochemical scheme and includes heterogeneous reactions. The UKMO stratospheric analysis data are employed for transport calculations.
Ozone profiles from the Microwave Limb Sounder (MLS) on board the Upper Atmospheric Research Satellite (UARS) were used in the assimilation. The obtained global distributions of ozone and other species will be presented.
The resulting three-dimensional ozone distributions were used to calculate the total stratospheric ozone column. Using the ozone climatology from Fortuin et al. (1995) the total ozone column was computed and compared with total ozone measurements from the Global Ozone Monitoring Experiment (GOME) on board the European Remote Sensing satellite (ERS-2). Results of these comparisons will be presented and discussed.

Storm track signature in total ozone during the northern hemisphere winter

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Total ozone has long been known to correlate with synoptic eddy activity, low total ozone being associated with anticyclonic conditions. Such eddy activity is particularly intense over the storm track regions of the North Atlantic and Pacific oceans during boreal winter. An Eulerian diagnostic was introduced by Blackmon et al. [1977] to investigate storm tracks, based on band-pass filtering the 500 mb geopotential height for synoptic time scales. Wintertime satellite observations of total ozone by the TOMS instrument are analyzed using the same time-filtering approach. Climatological storm track signatures in total ozone are described. The North Pacific signature is weaker than over the North Atlantic, and the cause of this asymmetry is explored. In the winter 1996/97, the Atlantic storm track was displaced westward and poleward due to persistent anticyclonic conditions over western Europe. Total ozone fluctuations on synoptic time scales were hence reduced over western Europe.

Validation of ground-based microwave measurements at the Bordeaux Observatory, France

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Ozone measurements are carried out by a ground-based microwave radiometer at the Bordeaux Observatory, (45°N, France). This instrument tuned to the 110.836 GHz ozone line uses a beam switching observation method. Ozone profiles are retrieved using the optimal estimation method in the altitude range 25-75 km. An error analysis has been completed, including measurement, model parameters and smoothing errors. Validation of results obtained over a three-year period (1995-1997) is presented. It consist of comparing Bordeaux retrieved profiles with ozone profiles provided by i) ground-based microwave measurements from the Bern University, Switzerland, ii) ground-based lidar measurements from the Observatoire de Haute Provence, France, iii) measurements, selected over the station, by the Microwave Limb Sounder instrument aboard the Upper Atmosphere Research Satellite, and finally iv) results from the 3-D SLIMCAT model.

DESIGN OF A NEW DIAL SYSTEM FOR TROPOSPHERIC AND LOWER STRATOSPHERIC OZONE MONITORING IN NORTHEN GREECE

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A new ozone DIAL system has been designed for tropospheric and lower stratospheric ozone monitoring in Northen Greece. The system is based on a quadrupled pulsed Nd:YAG laser and the Raman shifting technique in deuterium (D_2) and hydrogen (H_2) gases. The lidar system emits simultaneously 4 wavelegths (266 nm, 289 nm, 299 nm and 316 nm) using a single Raman cell. The optical receiving system is based on a 50 cm concave telescope which is coupled to a specially conceived spectrometer through a quartz optical fiber. This lidar system uses state-of-the-art analogue (12 bits-40 MHz) and photon counting (250 MHz) real-time detection systems able to measure lidar signals up 20 km height. Ozone vertical profiles are measured from 1 km up to 16 km height with a 50 m average spatial resolution and a 1-minute temporal resolution. In this paper the major technical characteristics of the new lidar system will be presented. The system is foreseen to provide the first ozone vertical profiles on May 1998 during the Photochemical Activity and Ultraviolet Radiation (PAUR II) European Campaign.

GLOBAL ATMOSPHERIC MONITORING WITH SCIAMACHY

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SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY) is a space based spectrometer designed to measure sunlight transmitted, reflected and scattered by the Earth atmosphere or surface. It is a contribution to the ENVISAT-1 satellite to be launched in late 1999.
SCIAMACHY measurements will provide amounts and distribution of O_3, BrO, OClO, ClO, SO_2, H_2CO, NO_2, CO, CO_2, CH_4, H_2O, N_2O, p, T, aerosol, radiation, cloud cover and cloud top height from atmospheric measurements in nadir, limb and occultation geometry. By the combination of the near simultaneous limb and nadir observations SCIAMACHY is one of a limited number of instruments which is able to detect tropospheric column amounts of O_3, NO_2, CO, CH_4, H_2O, N_2O, SO_2, and H_2CO down to the planetary boundary layer under cloud free conditions.
SCIAMACHY will provide new insight into the global behaviour of the troposphere and the stratosphere. Because of its wide range of applications SCIAMACHY is a good candidate instrument for any future global monitoring system.

SENSITIVITY OF PHOTOLYSIS RATES $J(O_1D)$ AND $J(NO_2)$ TO DIFFERENT ATMOSPHERIC CONDITIONS

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Modeling of the chemistry of the lower atmosphere requires photolysis rates of certain gases based on a radiation field which includes ozone absorption, molecular scattering and surface reflection. Meteorological conditions like clouds and aerosols also affect the actinic flux and have to be considered. Photolysis of ozone ($\lambda \leq 320$nm) is one of the most relevant primary sources for hydroxyl radicals via the reaction of $O(^1D)$ with H_2O. OH radicals are important for the tropospheric chemistry where they are involved in the oxidative composition of many man-made and natural trace gases such as CO, CH_4, SO_2 and CH_3CCl_3. The photodissociation of NO_2 ($\lambda \leq 420$ nm) provides the oxygen atoms required for photochemical ozone formation in the troposphere.
We used the model TUV (Madronich, 1997) to make modeling of the photolysis frequencies $J(O^1D)$ and $J(NO_2)$ and the sensitivity to solar zenith angle, overhead ozone column, cloud cover, aerosol loading, temperature, pressure and surface albedo is examined. A comparison with measurements of the photolysis rates under a variety of conditions commonly found in the troposphere will be used to stabilize the modeled data.

THREE-DIMENSIONAL SIMULATIONS OF OZONE IN THE STRATOSPHERE AND COMPARISON WITH UARS DATA

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A 3-D Atmospheric Chemical Transport model has been developed and used for the simulation of present-day trace-gas distributions in the troposphere and stratosphere. A 10-year-long steady-state model run for 1995 boundary conditions and circulation fields derived from the 24-layer UIUC AGCM has been carried out. The simulated distributions of ozone and radical species (e.g., NO,NO2, and ClO), which are responsible for the ozone destruction in the stratosphere, are compared with available observations made by the HALOE, CLAES and MLS instruments onboard UARS satellite. The comparison is carried out for monthly zonal-mean climatology for particular days and locations, and the correlations between different species derived from the simulated and measured data are calculated. The results of this comparison show reasonable agreement (within 30%) of the simulated and measured monthly zonal-mean ozone distributions, although the location of the simulated maximum in the ozone distribution is generally lower (about 2-3 km) than derived from satellite data. A substantial disagreement between the simulated and measured data occurs for particular days and locations, when the synoptic-scale variability of the ozone cannot be simulated by the model driven by the climatological circulation produced by the AGCM. The influence of the choice of chemical reaction set on the stratospheric ozone is estimated with additional short-term model runs.

CLIMATOLOGY OF THE REPROBUS CHEMISTRY-TRANSPORT MODEL COUPLED TO THE ARPEGE GENERAL CIRCULATION MODEL

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The REPROBUS Chemistry-Transport Model calculates the chemistry of the stratosphere whereas stratospheric dynamics is determined by the climate version of the ARPEGE General Circulation Model. Both models are coupled : ozone calculated by the full photochemical package of REPROBUS is taken into account in the radiative budget calculation of ARPEGE which in turn provides REPROBUS with temperature and winds. This allows interactive coupling between dynamics and chemistry. The strongest effect of chemical feedback upon dynamics is a modulation of the Antarctic vortex, related to the ozone depletion amplitude. Both models are run for several years for the current atmosphere and for the atmosphere of year 2015. The climatologies of both atmospheres will be presented and discussed, with particular emphasis upon the « Antarctic ozone hole » in the southern hemisphere, and stratospheric global warming occurences in the northern hemisphere. The climatology of the simulated current atmosphere will be compared to the Total Ozone Mapping Spectrometer (TOMS) and Upper Atmosphere Research Satellite (UARS) data.

OZONE VERTICAL DISTRIBUTIONS FROM GOME/ERS-2 SATELLITE DATA - I: COMPARISON WITH INDEPENDENT MEASUREMENTS

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The GOME (Global Ozone Monitoring Experiment) launched aboard ESA's 2nd European Remote Sensing Satellite (ERS-2) in April 1995 is part of the international scientific effort to improve our understanding of the natural and anthropogenic influences on the global ozone distributions. GOME is a nadir-viewing grating spectrometer covering the wavelength range 240-790 nm with a moderate spectral resolution of 0.2-0.4 nm. With the current scan strategy global coverage at the equator is achieved within three days, the horizontal resolution being 960kmx100km.
At the Institute of Remote Sensing the FUll Retrieval Method (FURM) was developed to derive vertical ozone distributions from GOME data. FURM is based on an optimized optimal estimation method, which in this form is being used in satellite remote sensing for the first time. The vertical resolution that can be achieved is of the order of 6-10km in the lower and upper stratosphere. For cloud free or low clouds scenes the tropospheric column can also be retrieved. The quality of the inferred profiles will be assessed by comparing them to selected ozonesonde profiles and other independent measurements.

THE ROLE OF WATER VAPOUR PHOTODISSOCIATION ON MESOPAUSE OZONE

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A one-dimensional atmospheric photochemical model is used to examine the structure of the global mean vertical ozone profile and its nighttime to daytime variation in the upper atmosphere. Two distinct ozone layers are predicted, separated by a sharp drop in the ozone concentration near the mesopause. This naturally occurring mesopause ozone deep minimum is primarily produced by the rapid increase in the destruction of water vapour, and hence increase in HO_x, at altitudes between 80 and 85 km, a region where water vapour photodissociation by ultraviolet radiation of the solar Lyman-alpha line is significant and where the supply of water vapour is maintained by methane oxidation even for very dry conditions at the tropospheric-stratospheric exchange region. The model indicates that the depth of the mesopause ozone minimum is limited by the efficiency with which inactive molecular hydrogen is produced, either by the conversion of atomic hydrogen to molecular hydrogen via one of the reaction channels of H with HO_2 or by Lyman-alpha photodissociation of water vapour via the channel that leads to the production of molecular hydrogen. The sensitivity of mesopause ozone to solar cycle uv flux variations and to increasing greenhouse gases is also examined. Recent observational evidence supports the predictions of the model.

ST15 Atmospheric ozone (co-sponsored by OA)

Convener: Hirschberg, M.-M.

02 Polar ozone

Convener: Krivolutsky, A.A.

POLAR OZONE AS OBSERVED BY ADEOS ILAS AND TOMS INSTRUMENTS

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The ILAS and TOMS instruments measured respectively the ozone vertical distribution and total ozone amounts during the 1996-1997 polar summer. Between 50 S and the south pole total ozone is characterized by a maximum centered near 60S and a decrease to a minimum of 200 to 250 DU at the south pole. Total ozone amount changes from month to month during the summer. Ozone amounts vary longitudinally with indication of wave structure. There is evidence of total ozone circumpolar transport and latitudinal transport toward the pole. ILAS ozone observations are confined to the 60 to 70 S latitude region. These profiles show altitude structure, which varies with time and location. Using back trajectory analysis and calculated pv maps, it is possible to trace the origins of stratospheric ozone at different altitudes ie. potential temperature surfaces. There is an indication of transport from lower to higher latitudes existing at some vertical levels and not others in agreement with ILAS observations of profile shape changes. This type of analysis can be used to evaluate the fine structure in the ILAS profiles. Total ozone amounts as observed by TOMS and ILAS are employed to validate ILAS. Northern hemisphere polar ozone data in the early spring are also analyzed.

MODELED OZONE LOSS IN THE ARCTIC STRATOSPHERE IN COMPARISON TO RESULTS OF THE MATCH EXPERIMENTS

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The Match technique determines chemical ozone depletion in the Arctic polar vortex from an analysis of pairs of ozone soundings probing the same airparcel at two different points of a calculated trajectory. It allows a quantitative comparison of the observed ozone loss rates with model results because the exposure of the probed airmasses to sunlight is known. We use a photochemical box model to simulate the Match experiments of the winters 1991/92 and 1994/95. The model severely underestimates the early winter ozone loss. Extensive sensitivity studies for the winter 1991/92 show that the discrepancy between model and Match results can not be explained by uncertainties of the model parameters.

A DISCUSSION ON THE VARIABILITY OF ATMOSPHERIC TRACE GAS CONCENTRATIONS AND OTHER HIGH LATITUDE PHENOMENA

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Routine measurements of atmospheric trace gas concentrations by ground-based monitoring optical instruments at high latitude facilitate studies of possible influences of different phenomena on atmospheric trace gases. In this study we use data from UV/visible DOAS instruments operated at the Swedish Institute of Space Physics in Kiruna in order to discuss the variability of O3, NO2, OClO, and BrO over a one-year period.
The initial study includes a discussion on the location of the polar vortex, the location and activity level of the auroral oval, cloudiness, and lightning. Only a few aspects of each individual high latitude phenomenon is quantified and related to the derived trace gas concentrations.

TOTAL OZONE CONTENT OVER MURMANSK

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Total ozone measurements have been performed by different organisations on a regular basis at Murmansk (φ=68.97^{0}N, λ=33.05^{0}E; Φ=64.5^{0}N, Λ=115.2^{0}E) since the beginning of observations in 1971 to 1997. All the data of ozone observations for the whole observation period are collected as a data base in the Geophysical Observatory Loparskaya. An initial analysis of collected data was implemented and it was noted that the total ozone content (TOC) at Murmansk during the last 27 years showed the decreasing of the one. A seasonal behaviour and other characteristics of TOC were obtained.

PSC LIDAR MEASUREMENTS INTERPRETATION BY A MIE MODEL

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PSC measurements from ALOMAR/RMR lidar has been classifyied in terms of backscatter measured at three wavelengths ($\beta_{aer}^{\lambda_{1,2,3}}$), Two values of lengthwave dependance of aerosol backscatter(Angstrom coefficient α) and Depolarisation (δ). The typical values of the optical parameters is different from previous classifications, especially for type Ib PSCs. A coherent behaviour of the α-β_{aer} relationship is found for each kind of PSC, but is slightly variable from mesurement to measurement. The first aim of this work is to define the sensitivity of optical measurements to changes in aerosol characteristics and to identify the cloud evolution in terms of size distribution parameters. To do this, β_{aer} and α are calculated by a Mie model with random selection of bulk parameters and refraction index inside the range for type Ib PSCs. Theoretical α and β_{aer} corresponding to measured ones are selected in order to characterise measured PSC's by random model parameters . Temperature has been measured simultaneously inside PSC by Raman Rotational technique during several events. Measured ($\beta_{aer}^{\lambda_{1,2,3}}$, α) and theoretical (size distribution average volume) aerosol parameters will be related to temperature changes.

OZONE MEASUREMENTS IN THE LOWER TROPOSPHERE OVER NY-ALESUND, SVALBARD (78^{0}55'N, 11^{0}53'E)

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Hourly surface ozone measurements made since 1991 at the Zeppelin mountain, Svalbard, using a UV-absorption ozone analyser are compared to coinciding ozone measurements from balloon borne electrochemical cell ozonesonde observations launched from nearby Ny-Alesund. By extending the surface ozone measurements with in-situ ozonesonde measurements, we attempt to establish the seasonal characteristics of ozone in the lower troposphere with respect to prevailing meteorological conditions and air-mass origin at different levels.

COMPARISON OF AIRBORNE LIDAR MEASUREMENTS WITH HIGH RESOLUTION TRACER TRANSPORT MODELS

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Stratospheric ozone and aerosol were measured during winter 94/95 in several campaigns with an airborne LIDAR system. The comprehensive set of vertical along-flight-track profiles inside, across and outside the polar vortex mirrors the development of the lower stratosphere during that winter. The LIDAR data are used to validate high resolution transport models which again complement the vertical along flight track information horizontally. This provides information about the height resolved ozone and aerosol distribution of the European middle and high latitudes. In this study a Contour Advection and a Domain Filling Trajectory code driven by winds from UKMO data assimilation are run to advect potential vorticity (PV) as air mass tracer. One of the most striking features of the measured ozone distributions is the pronounced small scale horizontal (~1°) and vertical (~1km) inhomogeneity with blob- and tilted stripe structures occurring throughout the winter in the lower stratosphere. It is shown that in many cases the filaments indicated thereby are reproduced by the models on various potential temperature levels. This confirms the relevance of dynamical processes peeling off narrow sheets of air from the vortex edge and subsequently transporting and diluting them to middle latitudes. Chemically induced ozone depletion previously reported for 21 March 1995 is confirmed and the transport of ozone depleted vortex air to mid-latitudes discussed.

Measurements of Stratospheric Ozone and Chlorine Monoxide over Ny-Ålesund, Spitsbergen, in 1997 and 1998

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Observations of stratospheric ozone and chlorine monoxide (ClO) are regularly being performed at the Arctic station of the "Network for the Detection of Stratospheric Change" (NDSC), using a ground based millimetre wave radiometer. While ozone has been operationally monitored since 1994 at an observation rate of about 20 profiles per day, ClO measurements are being restricted by the strong and variable absorption of tropospheric water vapour and the necessity of day and night time observations. The location of the observation site, Ny-Ålesund (78.9°N, 11.9°E), enabled us to take data inside the polar vortex in 1997. We observed enhanced levels of stratospheric ClO of up to 1.6 ppbv from late February to early April 1997 in the vicinity of 20 km of altitude. Considering diabatic processes, using our own ozone measurements for the calculation of atmospheric heating rates, we have derived chemical ozone loss rates of up to 20 ppbv/day in the same altitude range. A subsequent ozone loss of approximately 35% was measured over the complete ozone loss period. Besides details of this analysis we are presenting data of 1998 for both species.

SIMULATION OF THE DYNAMICS AND CHEMISTRY OF THE ARCTIC STRATOSPHERE DURING THE WINTERS 1995/96 AND 1996/97

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During the consecutive winters of 1995/96 and 1996/97 record low temperatures well below 195 K, the conventional threshold value for PSC-I formation, were observed in the lower arctic stratosphere. While the low temperatures in the former winter were caused by strong upper tropospheric blocking common to northern hemispheric winters, the latter showed a strong, less disturbed and persistent cold polar vortex, a feature usually observed in the antarctic winter stratosphere. In both winters the cold temperatures led to the formation of PSC's. The disturbance of the chlorine chemistry due to heterogeneous reactions and the subsequent ozone destruction resulted in unusually low ozone values in the northern hemisphere.
The aim of this study is to investigate the dynamical and chemical processes and their interaction during these episodes. A three dimensional mechanistic model of the middle atmosphere which is coupled with a chemistry and a transport module is used to simulate the two episodes. The data for the temperature fields used to force the model at the lower boundary region are taken from ECMWF analyses. The main results will be presented and compared to data derived from satellite measurements.

ANALYSIS OF INTERANNUAL VARIATIONS IN TOTAL OZONE AND STRATOSPHERIC CIRCULATION

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Using the monthly mean TOMS (version 7) data the linear trends of total ozone are calculated for each month in 1979-1992 and analyzed with a special attention to the longitudinal structure. Together with the well known negative trends the positive total ozone trends were revealed in the distinct regions in particular westward from Greenland in January-February. The relations between interannual variations of total ozone and stratospheric angular momentum (NCEP data) were investigated by means of the calculations of the empirical orthogonal functions (EOF) and singular value decomposition (SVD) analysis. The results indicated strong link of total ozone anomalies with stratospheric circulation variations especially during winter/spring seasons, which confirm the findings for the evolution of zonally average fields in 1979-1991. It may mean that observed ozone trends can be mostly caused by interannual and decadal changes of stratospheric wave activity. The possibilities to distinguish the long-term natural and anthropogenic impacts on ozone layer are discussed.

POLAR STRATOSPERIC CLOUD MEASUREMENTS BY LIDAR AND BALLOON BORNE SONDES AT SODANKYLÄ IN 1996/1997

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Series of PSC measurements were performed at an Arctic site Sodankylä (67 °N, 26 °E) during the winter of 1996/1997. The instrumentation consisted of aerosol backscatter and depolarization lidar and balloon borne backscatter sondes. In many cases it was possible to obtain aerosol backscatter and depolarisation profiles quasi-simultaneously by both instruments. We present a summary of all PSC measurements performed during January-February 1997. During January 1997 PSC temperatures at 50 hPa were observed in 13 percent of all radiosonde launches, which is the lowest for the last 6 winters for this altitude. On January 22-23, 1997 we observed type II PSC with the measured temperatures 6-8K lower than the synoptic scale temperature. On the other hand, 3-dimensional mesoscale numerical weather prediction models used in our study, were able to present realistic analysis of the temporal development of cold areas over northern Scandinavia, formed as a result of lifting of isentropic surfaces by mountain waves.

EVIDENCE FOR A SUBSTANTIAL ROLE FOR DILUTION IN NORTHERN MID-LATITUDE OZONE DEPLETION.

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Satellite measurements of ozone have shown a significant decline in ozone at mid-latitudes, and this has partially been explained by chemical models. Transport of air out the polar vortices has been shown to be modest, but after break-up of the vortex any ozone depleted air will eventually mix into mid-latitudes and cause a dilution there. For the Antarctic ozone hole this has been verified in model simulations. Here we show that the large ozone depletions in the Arctic vortex in spring 1993-97 lead to a dilution of northern mid-latitude ozone of about 2 % in 1993-94, which are comparable to TOMS trends in at 30-60 N May of 6 % from 1979-1994. In spring 1995-97 the dilution is about 3-4 %. These results indicate that dilution plays a substantial role in the mid-latitude ozone depletion in spring and summer, when the harmful effects of increases in UV radiation are largest.

QBO VARIABILITY OF TOTAL OZONE FOR ANTARCTIC SPRINGS AND ITS RELATION TO PLANETARY WAVES INTENSITY

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High resolution TOMS global data for each spring for 1979 - 1994 interval were used to study the correlation between the intensity of total ozone large-scale disturbances and ozone content over South pole during Antarctic springs with ozone hole"manifestation. The harmonic analysis procedure has revealed a strong QBO modulation of first harmonic amplitude with in phase of QBO oscillations of total spring ozone over South pole. The magnitudes of first harmonic reach of about 100 Dobson units for single years in contrast to the its smaller magnitudes at high latitudes of the Northen Hemisphere. The correlation coefficient between evolution of the first harmonic amplitude at 60 S in September and ozone content in October (after linear trend substraction) equals 0.7. The problem is to explain QBO effect in the planetary waves intensity.

THE 1998 ARCTIC OZONE DEPLETION QUANTIFIED FROM THREE-DIMENSIONAL MODEL SIMULATIONS

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Three-dimensional simulations of total ozone are reported for the 1997-98 Arctic winter. We used the REPROBUS chemistry-transport model which calculates the densities of 55 species or families of stratospheric interest, by means of a comprehensive photochemical package and a detailed description of heterogeneous reactions on liquid and solid particles. The comparison between the chemically integrated ozone and a passive tracer initialized like ozone allows to discriminate chemical changes from variations due to dynamical processes. This method is used to quantify the ozone chemical loss during the 1997-98 winter. Comparisons with ground-based and satellite observations are also presented.

NO_2 BALLOON-BORNE MEASUREMENTS DURING THE ILAS VALIDATION CAMPAIGN

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Measurements of NO_2 were performed on February 26, 1997 by the balloon-borne instruments LPMA and AMON before sunset, at sunset and at midnight, during the ILAS validation campaign at Kiruna (North Sweden). Vertical profiles have been obtained at very close location inside the polar vortex. These profiles will be compared to ILAS measurements of NO_2 performed also at the same date.
The data allows to study the diurnal variation of NO_2. The measurements will be compared to outputs of modelling works (box model and CTM 3-D model), taking into account ozone, chlorine and aerosol measurements also performed by the instruments. In particular, the existence of NO_2 below 23 km inside the aerosol layer, where modelling works predict zero value of NO_2 mixing ratio, will be discussed.

LIDAR OBSERVATIONS OF LEEWAVE INDUCED PSCS ABOVE ESRANGE IN NORTHERN SWEDEN

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For a quantitative understanding of Arctic ozone depletion the number, the timing, the duration, and the altitude of PSC events is a very important factor. According to the temperature analysis from the ECMWF in winter 1996/97 temperatures fell below PSC type I formation temperatures for only a few days in January 1997 and never reached PSC II formation temperatures above northern Scandinavia. In contrast our new backscatter lidar (light detection and ranging) on the Esrange (68°N) near Kiruna, Sweden, detected PSCs even on days when regional ECMWF temperatures were too high for any PSC formation. All types of PSCs were observed in this winter: very weak but depolarizing PSCs of type 1a with a backscatter ratio of 1.1 in parallel and 2 in perpendicular polarization, non depolarizing PSCs of type 1b with backscatter ratios of 3 to 5, as well as very strongly depolarizing PSCs of type 2 with backscatter ratios of up to 120 in parallel and 1600 in cross polarization. PSCs formed on 17 days over the lidar, most of them in January, a few in February, and one in March 1997. The altitudes of the PSCs ranged from 18 to 29 km. All of the "warm air" PSCs occurred when the windfield in the troposphere excited leewaves at the Scandinavian mountains which could propagate up to the stratosphere and lower atmospheric temperatures on a regional scale.

SIMULATION OF THE ANNUAL CYCLE OF TOTAL OZONE OVER NORTHERN HIGH LATITUDES AND COMPARISON WITH TOMS DATA

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The total ozone distribution in the polar area is a very informative indicator of the performance of a 3-D photochemical-transport model because it reflects the ability of the model to treat both dynamics and photochemistry in the atmosphere. On the other hand, the observations by TOMS provide a dataset that can be used for detailed validation of the simulated data. Accordingly, to estimate how successfully the total ozone distribution can be simulated, a numerical experiment with the 3-D UIUC Atmospheric Chemical Transport model has been carried out for 1993. In this simulation the distributions of trace gases are calculated with the model driven by circulation fields acquired from the UKMO dataset for 1993. A 3-year-long steady-state model run has been performed and the distribution of total ozone is compared with daily TOMS data for 1993. The comparison of the simulated and observed total ozone fields shows that the locations of the areas with high and low total ozone are simulated rather well. This means that the treatments of the chemistry and transport in the model are correct, and that the UKMO winds are very close to the true meteorological fields in 1993. The magnitude of the simulated total ozone field is slightly different from the observations and further improvement of the model is necessary to describe more accurately the destruction of ozone in the troposphere.

TRANSPORT RELATED O_3 VARIATIONS DURING THE AIRBORNE POLAR EXPERIMENT

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Reverse Domain Filling Trajectories (RDFT) analyses have been performed at the University of L'Aquila during the APE campaign to follow the vortex boundary movements and to obtain high resolution tracer fields used to examine the structure of the filaments eroded from the polar vortex edge. Focusing on the flights of 23/12/96, when the M55 Geophysika flew out of the vortex and across large filaments of inner-vortex and mid-latitude air, and 29/12/96 and 31/12/96, when a major intrusion of low latitude air into the vortex occurred, filament morphologies has been simulated and compared with O_3 data from the ECOC instrument onboard the M55. Similar filament morphologies can be found in tracers fields simulated for the same cases with SLIMCAT Chemistry and Transport Model (CTM) operating at the University of Cambridge. Coupled run and intercomparisons between RDFT and CTM calculation has been performed to understand our ability in reproduce the filament characteristics. Origin and characteristics of the global patterns responsible for the observed O_3 variations and reconstructed filament morphologies will be discussed.

TROPOSPHERIC OZONE RECORDING IN HIGH LATITUDES

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Surface ozone variations were measured at Svalbard (78 N) in August 1995 by Russian chemiluminescent ozone analyser AM-01. The surface ozone measurements were supported by ozone total content measurements with help of Russian M-124 filter ozonometer and were compared with some meteorological parameters. It was shown that the usual mean surface ozone concentration is equal to about 30 ppb and does not demostrate any diurnal course. Rapid surface ozone depletions up to 80% with duration from ten minutes to some hours and one intense enhancement of 120% value lasting about ten hours were discovered. A physical interpretation of such variations in terms of local topographically induced wind system which brings high bromine concentrations from surface sea water was suggested.

ROLE OF THE 11-YEAR SOLAR CYCLE IN A FORMATION OF THE WINTER VARIATIONS OF THE OZONE OVER NORTHERN EUROPE.

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On the basis of the monthly mean total ozone data for nine stations of Northen Europe for the period of 1957-1995 simple regression analysis of the connection between wintertime interannual variations of the ozone and the sunspot numbers is conducted. For the investigation the ozone data have been grouped according to the phases of the QBO. Simple regression analysis shows that the positive (negative) connection between the ozone and the solar activity is observed during the westerly (W) (easterly (E)) QBO phases. Results show that the influence of the 11-year solar cycle makes 1,1%, 7,4%, 35,2%, 35,6% of interannual variability of the total ozone over the region in months from December to March for the W QBO phase. For the E QBO phase this influence makes respectively 1,7%, 2,4%, 36,0% and 8,7% of the ozone variability. For the explanation of the obtained results simple regression analysis between the stratospheric indexes (30 hPa) over the region and the sunspot numbers is conducted. Regression model shows the similar dependencies as at the analysis of the Solar-Ozone relationship. As regression models applied for the ozone and for the indexes of stratospheric circulation over the region demonstrate similar results then it may be supposed that the Solar-Polar Ozone relationship is executed through the Solar-Stratospheric Dynamics relationship.

ON THE JOINT SOLAR/QBO EFFECT ON THE OZONE OVER NORTHERN EUROPE IN WINTERTIME.

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Using the monthly mean data of total ozone in months from December to March for the period 1957-1995 for Northen Europe stations the joint Solar/QBO effect on ozone variations is investigated. Correlation analysis conducted on condition that the data were divided according to the westerly (W) and easterly (E) QBO phases shows positive (negative) correlation between the ozone and the solar activity during the W (E) QBO phases. The highest correlations are obtained for February ($r = 0,63$ and $r = -0,59$ for the W and E QBO phases). To examine these statistical results all the ozone anomalies that exceed the standard deviation for a given month have been compared with solar activity. The comparison shows that almost all the ozone anomalies in February are in accordance with abovementioned statistical dependency. A correlation analysis conducted for the investigation of the connection between the stratospheric dynamics indices over the region and the sunspot numbers demonstrates similar results to ones for the Solar - Ozone relationship but in reverse ratio (for February $r = -0,65$ and $r = 0,59$ for the W and E phases). As close connection between the indices and ozone variations ($r = -0,70$ for February) is revealed then it may be concluded that the Solar - QBO - Polar Ozone relationship is executed through the stratospheric circulation.

THE THERMAL STRUCTURE OF THE ANTARCTIC LOWER STRATOSPHERE BEFORE AND AFTER THE DETECTING OF THE OZONE HOLE

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First results of an investigation upon the development of the thermal structure of the lower stratosphere of the southern polar region in dependence of ozone are shown.
From the reanalysis datasets of NCAR/NCEP and ECMWF meteorological parameters are taken. Ozone data are used from TOMS and additionally ozonesonde data are evaluated. Temperatures and zonal wind in different stratospheric pressure levels are applied to establish the variation of the thermal structure and the transition of the winter to the summer circulation during the period of 1979 to 1993. Undisturbed „pre-ozone hole" years are compared with. The relation of ozone concentrations and temperatures in a temporal and a spacial kind and in consideration of the polar circulation is described and quantified.
Periodical fluctuations like solar cycle and QBO and single events like volcanic eruptions are considered.

STRATOSPHERIC ARCTIC WINTER PROFILES OF N_2O, CH_4, H_2O AND HDO, MEASURED BY MIPAS-B

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Vertical profiles of CH_4 and H_2O inside the arctic vortex were retrieved from nighttime infrared limb emission spectra measured by the Michelson Interferometer for Passive Atmospheric Sounding, Balloonborne version (MIPAS-B) instrument from Kiruna (Sweden, 68°N) on February 11, 1995 and March 24, 1997. The results of the February flight show a peak mixing ratio of nearly 7.0 ppmv H_2O at 17.1 hPa and a minimum of 3.6 ppmv H_2O at 137.5 hPa corresponding to 28 km and 13.2 km altitude. The analysis of the March flight shows a similar profile, but the vertical gradient is less pronounced. The total hydrogen budget of the stratosphere has been examined by evaluating the quantity $[H] = [H_2O] + 2\,[CH_4]$. A mean mixing ratio of [H] is calculated from the data revealing high values of around 7.25 ppmv for both flights. A compact correlation between CH_4 and N_2O was also deduced from the measurements. From the spectra of the February flight a vertical mixing ratio profile of HDO has been inferred, too. The deuterium to hydrogen ratio (D/H) of water vapor shows a strong depletion in comparison to that of Standard Mean Ocean Water (SMOW) particulary in the lower stratosphere. These depletion is a hint of a possible dehydration by PSC particles which occurs at a lower altitude than that of the denitrification measured on the same flight.

STRATOSPHERIC CHEMISTRY MODELLING: RESULTS OF A BOX MODEL AND A THREE-DIMENSIONAL CHEMISTRY TRANSPORT MODEL

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A stratospheric chemistry routine is developed and tested in a box model. The routine contains 43 species and 154 reactions, of which 29 photolysis reactions and 18 heterogeneous reactions on ice, NAT and liquid aerosol. As a numerical solver Euler Backward Iterative is used, taking a 40 minute timestep and 10 iterations. This new routine is examined with the help of idealized trajectories and a previously validated box model.
The chemistry routine is then implemented in a three-dimensional chemistry transport model, TM3. This model is forced by analyzed ECMWF wind and temperature fields. Results are compared with ozone sonde measurements and other balloon- borne and aircraft measurements, which were carried out in the SESAME winter, 1994-'95.

ABOUT THE CHANGES OF THE OZONE CONTENT OVER THE EAST ANTARCTIDA

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It has been considered the ozone changes on the base of ozonesonding obtaining data from the German balloon station G. Foster (70° 46' South , 11°50' East) for the period 1985-1991. These data are compared with the derived results from the Russian station Mirnii (66° 33' South , 93 °01' East).The main statistical characteristics of vertical profiles are presented .A special attention is paid to the Spring reduction of the ozone content during October-November.After the detailed analysis it is concluded that the chemical ozone loss in spring is significantly controlled by dynamical processes. This dynamical control is understood as a natural impact on the polar ozone depletion As it can be shown the strong circumpolar vortex circulation weakens the advection of air towards polar latitudes.

ST15 Atmospheric ozone (co-sponsored by OA)

Convener: Hirschberg, M.-M.

03 Changes in UV-B radiation

Convener: Krüger, B.C.

THE DEPENDENCE OF THE SOLAR UV-B RADIATION ON TOTAL OZONE AND SOLAR ZENITH ANGLE

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The contribution reports on an analysis of solar UV-B radiation measurements made by RB-Biometers simultaneously in two locations: Hradec Králové (285 m a.s.l.) and Milešovka (836 m a.s.l.). The analysis of the series of 10-minute sums obtained during one year (96/8 - 97/7) is focused on (i) comparison of the UV-B radiation regime in the two locations, and (ii) determining the dependence of UV-B radiation on total ozone and solar zenith angle. Using the regression relations determined in the latter step, the changes in local UV-B radiation climatology due to changes in total ozone will be deduced.

The analysis is made within the frame of a joint grant project of the Czech Hydrometeorological Institute and Institute of Atmospheric Physics. The project aims at: (i) monitoring of biologically active UV-B solar radiation, (ii) assessment of relations between total ozone and UV-B radiation, and (iii) creation of the information system for operative reports on UV-B levels and exposure times recommended for population.

CAN INCREASED UV RADIATION CAUSE SURFACE OZONE EPISODES?

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A case study is presented which shows a remarkable coincidence of very low total ozone and high near-surface ozone concentrations (>60 ppb) in Switzerland in February 1993, lasting one week. The meteorological situation changed little during this period, and a high-pressure system provided good conditions for photochemistry on a regional scale. The reason for the low total ozone probably is anomalous stratospheric circulation and a chemical effect of Pinatubo aerosols.
Total ozone contains information about the tropospheric circulation which is an important influence on surface ozone concentrations in winter. However, it can be shown that during the episode surface ozone concentrations depended largely on photochemical ozone destruction (at the high-alpine site Jungfraujoch, 3580 m asl, with ~0.05 ppb NO_X) or production (at the elevated site Chaumont, 1140 m asl, with ~4 ppb NO_X) while transport was weak. The mean diurnal ozone cycles show an increase of ozone concentration at Chaumont and a decrease at Jungfraujoch during the afternoon hours. The amplitude at Chaumont is 8 ppb which is comparable to summer conditions. Such a strong photochemical activity is not expected in late winter. As ozone production at Chaumont at that time is limited by solar radiation rather than by precursor concentrations, the strong photochemical activity is probably due to enhanced radiation. This can be caused by two effects: the backscattering at a fog layer and the increased UV radiation due to low total ozone. The latter influence can roughly be estimated. Compared to normal conditions, the 30% negative deviation of total ozone observed (243 DU) leads to an increase of ozone photolysis of up to 80%. It is suggested that in this extraordinary case increased UV radiation lead to increased photochemical activity and caused an early surface ozone episode.

OZONE AND QBO VARIATION IN THE EQUATOR ATMOSPHERE

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Quasiblennial oscillations (QBO) of the ozone concentration and temperature, which occure in phase with the quasibiennial variations of the solar ultraviolet are discussed. Physical mechanism for ozone influence on QBO of equatorial east-west stratospheric zonal wind are proposed. These winds are transfered to the troposheric heights with turbulent diffusion and can influence on the dynamic of atmosphere. Thus the solar activity controls the origin of atmospheric circulation with QBO period. This can explain the initiation of some planetary atmospheric events in particular $ENSO$, which varies with double-QBO period.

UV-B RADIATION AND OZONE BEHAVIOUR AT ROME STATION IN THE RECENT SIX YEARS

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It is well known that the total ozone depletion is the main factor influencing the changes in solar UV irradiance at the earth's surface. At the midlatitudes an ozone decline associated to UV-B increase was observed (Kerr and McElroy, 1993; Zerefos et al., 1995; Seckmeyer and McKenzie, 1992).
The solar UV-B (290-325nm) irradiance and daily total ozone data have been collected by Brewer spectrophotometry at Rome station since 1992. The below normal ozone episodes during the period 1992-1998 are derived from the comparison between actual data and ozone long time series. The UV-B daily irradiances are analysed taking in account various atmospheric influences, such as cloud cover, turbidity and ozone content. Fluctuations, trends and anomalies in UV-B series are described and considered as a function of various temporal scales and dominating factors.

THE INFLUENCE OF RADIATION ON TROPOSPHERIC CHEMISTRY.

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The effect of changes in the solar radiation on the chemistry of the troposphere has been investigated for a wide range of concentrations of hydrocarbons and nitrogen oxides, which covers many possible cases from clean to strongly polluted areas. Such changes of radiation might be caused by a reduction of the stratospheric ozone layer or by the variability of the atmospheric aerosol content. Model calculations were performed, which show, that the concentrations of atmospheric oxidants like ozone, hydrogen peroxide, nitric acid or PAN increase with stronger ultraviolet radiation in most cases.

LONG-TERM CHANGES OF THE SURFACE UV RADIANCE AT BELSK, POLAND, 1966-1996

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The measurements of the daily UV dose by means of the Brewer spectrophotometer (1993-1996) and the Robertson Berger meter (1976-1992) are combined to form the time series of the monthly means of the UV daily dose (erythemally weighted) for the 1976-1996 period. The UV time series for the 1966-1976 period is reconstructed based on the statistical model using the measured values of total ozone and global sun radiation (used as a proxy for the cloud and aerosols effects on the UV) as the UV predictors. The reconstructed UV data for the 1966-1976 period shows a downward tendency. It seems that the global radiation changes influence mainly the UV level in that period. An increase in the UV dose of about 6% per decade (statistically significant) is forced by the total ozone depletion (about 4% per decade) over Belsk in the 1976-1996 period. The long-term variations of the UV dose based on the model running for the 1976-1996 period are almost the same as those from the measurements. This suggests that the long-term changes in other the UV forcing factors (e.g. ozone profile, optical characteristics of the clouds and aerosols) do not affects the UV trend significantly.

Maximum UV-Levels Measured on Alpine Radiation Stations

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In the Swiss Alps UV-radiation is continuously measured at the radiation stations Davos (1610 m a.s.l.), Weissfluhjoch (2540 m a.s.l.) and Jungfraujoch (3580 m a.s.l.). UV-measurements are based on erythemally weighted UV-Biometers which predominately measure UV-B radiation, and broadband filter instruments measuring the UV-A part of the spectrum. Three UV-Biometers measure direct, diffuse and global UV-B components and are periodically exchanged and calibrated. At Davos and Weissfluhjoch an instrument with a 2 pi full view angle is mounted on a solar tracker to measure maximum UV-B radiation normal to the sun. Ground reflected components are measured at the station Weissfluhjoch. Analysis of measurements from the last two years focus on maximum UV levels for the different components. Clear sky maximum levels are compared to broken cloud cases for different integration times. 2 pi full view angle measurements for different solar zenith angles are compared with respect to the orientation of the instruments, for snow covered (winter) and uncovered (summer) surfaces.

VOLKANIC ERUPTIONS IMPACT ON ULTRA VIOLET RADIATION REGIM

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The response results of all UV flux radiation components (direct, actinic, upward, downward) in polar, middle and tropical latitudes on volcanic aerosols presense in the atmosphere after Penatubo and Al Chichon eruptions are presented in the report. For influence estimation of aerosols distribution fine structure the new model of UV radiation fluxes counting was developed. The model uses Edington delta method for approximate radiation transfer equation solution and high precise matheatical apparatus for providing high altitude (to 1 meter) and wave length (to 0.01 nm) resolutions and automatical fine structure searching. This model takes into account Rayleight and many-times scattering, ozne, aerosol and cloudiness delution and layer surface reflection.
In the report the dependance of altitude structure and stectral distribution of our flux components transformation on volcanic aerosol distribution in middle and polar latitudes were analysed. The most interesting dependances are observed in the upward radiation spectral behaviour normed on the undisturbed radiation level. Upward flux responce on ozone change after eruption appear in local spectral maximum situated in the spectral areas 303 nm, 25% (tropics), 312 nm , 13% (middle) and 320 nm, 12% (polar) for Penatubo eruption.

IMPACT OF OZONE PROFILE ON THE SURFACE UV RADIATION: ANALYSES OF THE UMKEHR AND UV DATA TAKEN AT BELSK, POLAND, 1976-1996

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The trend analysis of the monthly means of surface UV daily doses (erythemally weighted) reveals an increase of the UV level at Belsk, Poland, of about $6\% \pm 1.3\%$ per decade since January 1976. An impact of the ozone profile changes on the UV irradiances at the ground level is studied based on the Umkehr data. Temporal variations of the ratio of the ozone content in Umkehr layers 1-4 (about 0-23km) and that in Umkehr layers 5-10 (about 23-48km) is used as an index of the ozone profile changes over Belsk. The 1976-1996 trend in the ratio is $-5.2\% \pm 1.4\%$ per decade suggesting the stronger ozone depletion in the lower stratosphere than that in the upper stratosphere. Both the statistical model (regression of the UV monthly dose on monthly means of total ozone, global sun radiation, and the above mentioned ratio) and the radiative transfer model (LOWTRAN 7) show that the ozone profile changes over Belsk influence only slightly the long-term variations of the surface UV radiation there.

USING SATELLITE MEASUREMENTS FROM GOME FOR THE ESTIMATION OF THE UV IRRADIANCE AT THE EARTH'S SURFACE

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We present some preliminary results of global UV fields estimation at the Earth's surface computed using data from the GOME instrument. A first simple model is used to test the best strategy for implementing the cloud modelling. It relies heavily on the cloud coverage estimation from GOME (ICFA and PMD measurements). A second, more accurate model will include the best approach and will be derived from the algorithm developed for the TOMS instrument by NASA/GSFC.

SNOW AND CLOUDS EFFECTS ON THE ERYTHEMAL UV RADIATION. ANALYSIS OF SWISS MEASUREMENTS AND MODELIZATION

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Direct, diffuse and global erythemal UV radiation are continuously measured at Davos (1610 m a.s.l) and Payerne (490 m a.s.l.) by using UV-Biometers (Solar Light Co, model 501). This data set and a radiative transfer model (two-stream TUV) are used to estimate the effect of a snow covered surface as well as of a cloud cover on the erythemal UV radiation.
In the presented analysis, the data at Davos from May 95 to April 96 were normalized to a constant total ozone amount (300 DU) and constant distance sun-earth (1AU) to avoid any influence of these factors.
The clear sky radiation in case of a snow covered surface (winter) is found to be 20-30% higher than without snow (summer), with an enhancement increasing with increasing zenith angle (40-60°). The snow effect for winter aerosol conditions is estimated by using the radiative transfer model. The attenuation due to a cloud cover is estimated for snow covered surfaces and snow free surfaces. The average attenuation is found to be 60-64% for a snow free surface, and 50-56% for a snow covered surface. The radiative transfer model is used to get an estimation of the optical depth of the cloud cover.

RELATIONSHIPS BETWEEN THE ATTENUATION OF SURFACE UV IRRADIANCE AND THE RADIATIVE PROPERTIES OF THE SATELLITE-DERIVED CLOUD FIELD.

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Cloud observations from the International Satellite Cloud Climatology (ISCCP) dataset are combined with spectral and broadband surface UV irradiance measurements to study the effect of varying cloud radiative properties on solar radiation received at the ground. From the satellite observations, cloud cover, cloud optical thickness, and cloud top pressure are retrieved and are used to derive radiometric definitions of cloud type. The global irradiance data are then correlated with the radiative properties of the cloud field, and the relationships between cloud type and the attenuation of surface UV irradiance are examined. In parallel, the satellite data are compared with conventional cloud observations from local meteorological stations to investigate the differences of the two methods and their suitability for use in solar radiation studies. The UV irradiance data used in this study are obtained from a Brewer spectroradiometer operating at Thessaloniki and from the network of broadband detectors of the University of Thessaloniki, covering a wide area over Greece. The analysis is done for two months, one in the summer and one in the winter season.

ST15 Atmospheric ozone (co-sponsored by OA)

Convener: Hirschberg, M.-M.

04 Tropospheric ozone with emphasis on the Mediterranean region

Convener: Varotsos, C.

Tropospheric ozone contribution to surface warming at Athens, Greece

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The atmospheric greenhouse effect and its contribution to global climate change are of great importance the last decades. The tropospheric ozone as a greenhouse gas has a significant role to the overall greenhouse effect. In this study an estimation of the greenhouse effect over Athens, Greece, as deduced from satellite data up to 1992 and the contribution of tropospheric ozone is attempted. Additionally, the trend of tropospheric ozone is examined for the time period 1992-1997 in order to assess its contribution to the atmospheric greenhouse effect up to 1997.

Free tropospheric ozone variations at Athens, Greece

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Many uncertainties still exists concerning the stratosphere-troposphere exchange (STE) of ozone. STE mainly occurs during the mid-latitude tropopause foldings as well as during cut-off low events. In the present study the stratosphere-troposphere ozone exchange over Athens, Greece, during the period from 1991 to 1997 is examined in relation to the presence of a cut-off low pressure system in the upper troposphere or a possible tropopause folding, when the station is close to the flank of an upper level trough. For this examination, the ozonesounding data during the above mentioned period are used along with the corresponding prevailing meteorological situation.

SHORT AND LONG TERM VARIABILITY OF THE VERTICAL OZONE PROFILE IN THE MEDITERRANEAN REGION

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The impact of Mediterranean emissions on free tropospheric ozone will be discussed using, on one hand, a study of a long term time serie of ozone profiles measured at the Observatoire de Haute Provence (OHP) in Southern France, and on the other hand, a vertical cross section of ozone measured in September 1996 along the East coast of Greece. The OHP time serie shows no positive trend of the yearly ozone mean during the 80's, but a significant change of the seasonal variation consistent with increased photochemical production in the summer. The importance of photochemistry is confirmed by the absence of a significant change in the strength of stratospheric ozone transport to the troposphere. The discussion of this climatological analysis will include a presentation of the data validation procedure which is mandatory for such a study. In order to illustrate the importance of Mediterranean emissions on ozone in the free troposphere, an example of an ozone rich layer transported from Spain to Greece will be discussed using airborne lidar measurements and meteorological analysis.

STUDY OF THE OZONE SINK ONTO ULTRAFINE AEROSOL PARTICLES.

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Since both the ozone and aerosols are very important atmospheric contaminating components, and taking into account that ozone can promote the formation of aerosol particles and, on the other hand, aerosol particles can cause ozone destruction the investigation of the interrelation between these components very important for the interpretation of their transformation in the atmosphere. For the most part, information on this problem is based on the data obtained during experiments carried out under laboratory conditions. In this paper we try to estimate the ozone sink based on the data obtained during measurements of ozone and aerosol concentrations in the real atmosphere. In 1993 in the framework of TOR project (EUROTRAC programme) the station for ozone monitoring (TOR-station) has been constructed in the Institute of Atmospheric Optics (Tomsk). All measurements of ozone concentration are accompanied with measurements of all standard meteorological quantities. In 1996 a diffusion battery was include to the measurement complex of this station. It allowed us to measure a number concentration of aerosol particles in the 3 to 200 nm diameter range. As a result of these measurements we have obtained continuous series of ozone concentration and aerosol size distribution in the surface boundary atmospheric layer near Tomsk. The rate of the ozone sink onto ultrafine aerosol particles is estimated.

STUDYING PERIODS OF HIGH OZONE CONCENTRATIONS IN THE MEDITERRANEAN REGION DURING A 7-YEAR PERIOD

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Tropospheric ozone is one of the most harmful pollutants causing damages to human health and plants. According to the EU regulatives the population should be informed when the hourly values of the ozone concentrations are greater than 90 ppb. Moreover, warning must be sent whenever these values exceed 180 ppb. The damaging effects on vegetation depend on the magnitude of the cumulative ozone exposure. Therefore both the damaging effects on human health and on plants must be carefully studied. The long-range transport model, the Danish Eulerian Model (DEM), has been used in this work. Meteorological data from 7 consecutive years, from 1989 to 1995, have been used in different scenarios for varying emissions of NOx and VOC. Advanced visualization techniques are used to interpret this large amount of digital data. The model results have been compared with measurements taken at stations located in the Mediterranean region. Furthermore, DEM has been coupled to the effect model (TreGro) in order to determine the impact on trees. It is shown that the information and warning threshold for the EU population, and the cumulative ozone exposures for plants are highly exceeded in most of Europe and especially in the Mediterranean region.

PECULIARITIES OF THE OZONE FORMATION IN THE BOUNDARY LAYER OF THE ATMOSPHERE OVER SOME REGIONS OF THE FORMER USSR.

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Since 1988 till 1991 the Institute of Atmospheric Optics has carried out regular airborne sounding of ozone over the whole territory of the Former USSR in the lower troposphere up to 8 km altitude. The data processing showed that the most significant peculiarities of ozone generation occur in the boundary layer of the atmosphere. There is only small latitudinal gradient above the boundary layer of the atmosphere. These peculiarities lies in the following facts. Altitude and intensity of ozone concentration maximum depends on properties of underlying surface. The highest altitude and intensity were recorded over regions covered by forests. There is longitudinal gradient of ozone concentration in the boundary layer of the atmosphere which is oriented from eastern to western regions. There is a lower surface inversion which results in two-layer ozone generation. In the boundary layer of big industrial centres, emissions from enterprises influence the strength of the ozone concentration maximum. They reduce its level. The ozone concentration decreases in the presence of the atmospheric fronts. It is regenerated during next 1 or 2 days. This study was financed by Russian Foundation of Basic Studies (grant № 96-05-64332).

EARLY SPRING OZONE EPISODES: OCCURRENCE AND CASE STUDY

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In Switzerland, near-surface ozone concentrations exceed 60 ppb for the first time of the year often already in February. Elevated rural sites (Chaumont, 1140 m asl, Rigi, 1030 m asl) first show these ozone peaks. They are sited 600-700 m above the Swiss Plateau, which can form at that time a pool of cold, NO_X-rich air. Later, in April, rural lowland stations also show high peaks, while elevated sites already have monthly means of up to 50 ppb. Ozone peaks above 60 ppb in early spring (Feb-Apr, 1992-1997) typically occur in episodes of several days with high solar radiation and air temperature maxima above 6 °C. The corresponding NO_X daytime mean at elevated sites is 5-10 ppb, which is close to the optimum concentration for ozone production. While in the lowland, NO_X concentrations can be too high for efficient ozone formation, the key limitation at elevated sites in early spring is the solar radiation.
On fair weather days in early spring, the daily cycle of ozone concentration at elevated sites shows a clear maximum in mid-afternoon. Thermotopographic transport of emissions from lowland sources influences the precursor concentrations, however, ozone is probably mainly produced above the lowland due to chemical limitations. More rarely, ozone peaks occur after sunset or in the early morning, indicating vertical or horizontal transport, possibly in reservoir layers. In all, early spring ozone peaks are caused by *in-situ* photochemical ozone formation rather than transport.
A case study of 16-21 March 1990 shows a large scale ozone episode associated with a slowly eastward moving high-pressure system and high temperatures in Central Europe. Data from sites aligned west-east at different elevations in Switzerland, Tyrol, eastern Austria, and central Hungary show an increasing (from 70 to 100 ppb) while slowly eastward moving ozone peak. It is suggested that ozone was formed in a large area travelling 1000 km within 3-4 days within the anticyclone.
The study shows that long-lasting anticyclonic conditions, which were a dominant feature in spring 1996 and 1997 in Central Europe, can promote considerable photochemical ozone formation on a regional to large scale already in early spring.

ON THE ROLE OF AIR POLLUTION ON THE SOLAR RADIATION REACHING THE GROUND

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Solar Ultraviolet Rariation (UV-A and UV-B) measurements at Athens, Greece (380N, 240E) are examined with respect to the influence of photochemical pollution. Furthermore results of UV irradiance as deduced from a simple parametric model are compared with actual field measurements. The results show that the hypothesis of UV-B depletion is significant at an almost 95% confidence level. It is also shown that photochemical pollution effect on UV-B is as three times larger as on UV-A irradiance levels.

TROPOSPHERIC OZONE RELATED CHANGES IN BIOLOGICALLY ACTIVE ULTRAVIOLET RADIATION

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The influence of temporal surface ozone variations on the solar ultraviolet radiation reaching the ground is investigated. Comparison between historical (1900-1940) and recent (1987-1997) surface ozone data, monitored at Athens is discussed, in order to detect the plaussible variations in Ultraviolet Radiation reaching the ground. Furthermore the confirmation of the hypothesis that increased levels of atmospheric pollution may act as filter to the transfer of solar ultraviolet radiation to the surface is attempted.

APPLICATION OF CHEMILUMINESCENT OZONE ANALYZERS UNDER GEOPHYSICAL AND LABORATORY EXPERIMENTS

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It is known that the chemiluminescence observed during the oxidation of organic substances in heterogeneous conditions is used as a basis for building inexpensive, yet rather sensitive, contact-type gas analyzers for ozone. Having light weight, long life time, high response time and sensitivity such analyzers are used for solving tasks of ozone atmospheric monitoring and laboratory research. However by the moment the features of chemiluminescent sensors applications for the ozone concentration measurement under extending dynamic range conditions as well as interference of measured concentration range and life time duration, sensitivity stability in time of chemiluminescent sensor were not studied enough. This paper investigates some features of heterogeneous chemiluminescent ozone sensors operation, limits for the sensors application and measurement procedures based on chemiluminescent sensors and system analysis of sensors metrological specifications. Requi rements for the design of chemiluminescent ozone analyzers used as a part of automatic atmosphere pollutant control stations and analytical laboratories have been formed.

On the seasonal variation of photo-oxidants at the greater Athens area

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On the present study, the seasonal variation of photo-oxidants O3 and Ox (Ox=O3+NO2) is examined. Analysed data concern the period 1990-1996 and cover the whole greater Athens basin. The seasonal analysis concerns Summer (May-August), Winter (November - February) and transition (March, April, September, October) periods. Analysed data have been devided into three categories (24-hour, daytime and night-time) and the major statistical parameters were examined (mean value, median, standard deviation). Parallel to the seasonal variations, plaussible correlation between surface ozone and Ox concetrations are discussed. Results show a pronounced decline on surface ozone concentrations during the last years.

GAS PHASE REACTION OF HYDROXYL RADICAL WITH THE NATURAL HYDROCARBON BORNYL ACETATE

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The gas phase reaction of bornyl acetate (bicyclo[2,2,1]-heptan-2-ol-1,7,7-trimethyl-acetate), VOC emitted by Mediterranean trees (orange and mandarin trees) with hydroxyl radical has been studied. The rate constant determined at 294 ± 2 K is $k = (13.9 \pm 2.2) \times 10^{-12}$ $cm^3.molecule^{-1}.s^{-1}$. The experimental rate constant has been compared with the rate constants calculated with the structure-activity relationship (SAR) and with the evolution trend of the acetate rate constants. 1,7,7-trimethyl-bicyclo[2.2.1]-heptan-2-one, 1,7,7-trimethyl-5-acetyloxy-bicyclo[2.2.1]-heptan-2-one and 1,7,7-trimethyl-6-acetyloxy-bicyclo[2.2.1]-heptan-2,3-dione were identified as degradation products. Their estimated formation yields were very low (< 1 %). The reaction of bornyl acetate with OH radical leads to organic aerosols. The fraction of the carbon initially present that is converted to aerosol, has been estimated to about 5%. 1,7,7-trimethyl-6-acetyloxy-bicyclo[2.2.1]-heptan-2,3-dione has been identified as aerosol product.

On the statistical analysis of tropospheric and stratospheric ozone content over Athens Greece

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This study reports observations of the total ozone content (TOC) made by Dobson spectrophotometer at Athens Greece (38N,24E) for the time period 1994-1997. We have also used the ozonesoundings performed regulary at Athens, the same time period in order to define by integration the total tropospheric ozone amount. The final purpose is to separetely study both the tropospheric and stratospheric total ozone content by means of Fourier analysis paying special attention to the TOC minimum at 1996.

A STATISTICAL MODEL FOR THE RELATIONSHIP OF OZONE AND ITS PRECURSORS AT ATHENS BASIN

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Concentrations of surface ozone and its precursors (Nox and hydrocarbons) at Athens Basin are correlated with the temperature at 850 hPa level. The expression of the relationship of ozone to its precursors via polynimial and multiplicative regression models is attempted. Results show that, according to the regression models, the correlation coefficient increases from 0.73 to 0.98

ON THE ORIGIN OF THE ELEVATED SURFACE OZONE CONCENTRATION IN SPAIN

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The objective of this work is to study the influence of three mechanisms in the high surface ozone concentration of the Spanish EMEP stations. These mechanisms are: Photochemical production from organic compounds and nitrogen oxides, exchange of air between the Planetary Boundary Layer and the free troposphere and the advection of ozone. To do this we have designed a new method that use multivariate analysis and the average ozone concentrations, NO_x concentrations, leght of the air mass trajectories reaching the stations and emissions of NO_x. Results suggest that high surface ozone concentrations are controled by photochemical production if the source is close to the station. If the distance from the source to the station rises, the influence of the NO_x emissions become more important.

GEOGRAPHYCAL SOURCES OF SURFACE OZONE IN SPAIN

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Geographycal sources of surface ozone in five Spanish EMEP stations are studied using the air mass trajectories that arrive at the stations together with the CPFs (Conditional Probability Functions). Results show that regions with strong NO_x emissions placed far away the stations are the main sources of ozone in Spain. So, the center of Europe and the middle Mediterranean area are the two main geographycal sources of surface ozone in Spain.

MONTHLY VARIATION OF THE SURFACE OZONE IN SPAIN

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This study summarized the analysis of the monthly ozone concentrations done in five Spanish EMEP stations. From of the five considered stations show the typical natural spring maximum. This maximum extends into summer in two of the stations. In one of the stations the maximun is reached in summer and it is due to the proximity of this station to strong nitrogen oxide emission areas.

DIURNAL VARIATIONS OF THE SURFACE OZONE IN SPAIN

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In this study we present the diurnal and monthly variations in the surface ozone concentrations of five Spanish remote stations belonging to the EMEP network. In one of the stations the diurnal cycle is dominated by the breeze wind flow regime reaching a peak in the morning. In two of the stations, a maximun in the afternoon is presented because of the turbulent mixing producing appreciable downward ozone flux. In the order two stations no maxima are produced. In one of them this result is due to the strong westerly winds that dominate the air flow and the low solar insolation. In the other station the reason are two phenomena: the mountain induced flow regime that produce high concentrations during the night and the photochemical production that results in high concentrations during the afternoon.

TRANSPORT OF OZONE AND ITS PRECURSORS FROM SOUTH EUROPE REGION AND ITS INFLUENCE ON OZONE LEVEL IN LITHUANIA

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According to separate authors surface ozone concentrations in rural areas of Europe have been increasing at a rate of 1 to 3% per year over the past two decades. Surface ozone data show an increase by 2.5% per year over 1982-1996 at the coastal rural station Preila, Lithuania. An increase of ozone maximum concentration by 1% per year during this period is observed. The ozone level increase in Lithuania is mainly determined by the transport of polluted air masses rather than by local pollution. The ozone and its precursors concentrations are analyzed during episodes when the air mass from south Europe reached the Lithuanian territory. The air mass transport from this region is registered when the eastern part of the southern cyclone moving via the Czech, Poland and the Baltic sea reaches the Lithuanian territory. The southern air mass transport is observed also in the front part of the cyclone that is moving over north Poland from the West Atlantic Ocean. More rarely the southern transport is determined by the settled western part of a powerful Siberian anticyclone. The investigated cases were grouped over cold and warm periods of the year. Air masses from south Europe during the warm period are mostly distinguished for high ozone (>70 ppb) and other species level. During the cold period ozone concentrations are usually under 50 ppb.

On the Ozone Content of the free troposphere over Athens Greece as derived by using in situ techniques

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Ozone Content of the free troposphere over Athens Greece during the winter-spring period is examined based on observations made by using the ozonesounding technique. This study covers the period 1991-1997 when intensive ozonesounding campaigns took place at Athens, Greece (38 N, 24 E). Variations of tropospheric ozone are correlated with the corresponding Total Ozone Content (TOC) ones during the same period. The impact of prevailed meteorological condition is discussed. Additionally integrated TOC values as derived from ozonesounding profiles, Dobson #118 spectrophotometer and TOMS/SBUV satellite born measurement are cross examined. Finally a first approach on the evaluation of satellite born SBUV data concerning the lower atmospheric ozone content is attempted.

TIME VARIABILITY OF GROUND OZONE CONTENT WITHIN DIFFERENT CLIMATE REGIONS OF THE EARTH

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The time variability of ground ozone content has as regular pseudoperiodical) so unregular character. The first type of variability is caused by sunearth connections as well atmosphere general circulation and wave motion. The statistic analysis of ozone experimental data has been carried out to determine different fluctuation periods from minute to season variations for various climate regions from polar to tropical latitudes. Daily, 48 hours and season variations are shown evidently.The variations with shorter periods depend on many factors including observation latitude, profile and type of ground surface. An interference of wave processes of different origins which is responsible for period duration changes is assumed to exist. A special attention was paid to the nature of fluctuations with periods from 5 to 7 minutes. The second type of variability is caused by aperiodic atmospheric processes in particular by discharging ozone destructing and ozone generating substances of different concentrations and flow rates into atmosphere. Sources of aerosols of different nature as well nitrogen oxides, organic substances have a special significance. Experimental data on ozone concentrations in dependence of aerosols and nitrogen oxides are considered.

SURFACE OZONE CONCENTRATIONS AT RURAL LOCATIONS IN POLAND IN 1996

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The results of surface ozone measurements performed at five stations are presented. Measurement stations are lokalized out of direct influence of pollution sources (except station in Warsaw). The results of ozone measurements give us the information how high are ozone concentrations and their daily and seasonal variations in various regions of Poland, regarded as having clean or almost clean air. Frequent epizodes of high ozone concentration were observed at all stations in the first half of 1996. First of them occured in February, when daily means at rural stations were above 100 $\mu g/m^3$. Similar episodes occured in March, April and June. Analysis of episodes indicate that they were caused (except the last one) by dynamical transport of air from the upper layers of the atmosphere. Analysis of ozone concentrations dependence on meteorological parameters and other gaseous pollutants (NO_2, SO_2, CO) for Belsk station indicates that dynamical processes (vertical and horizontal airmass transport) have substantial influence on changes of surface ozone concentrations.

FIVE-YEAR RECORD OF OZONE AT MT. BROCKEN (GERMANY) - IMPLICATIONS FOR CHANGING HETEROGENEOUS CHEMISTRY

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Theoretical studies using models with coupled gas and liquid phase chemistry suggested that not only the net formation of ozone could be reduced in clouds but also heterogeneous destruction could be possible. Several possible pathways of ozone sinks in clouds we discussed recently concerning first experimental findings of ozone depletion at Mt. Brocken [Acker et al., 1995]. Since 1992 we record the ozone concentration beside several other air and cloud chemical and physical parameters at Mt. Brocken. Now we present the changing seasonal amplitude of ozone (increasing winter ozone concentration whereas the summer ozone remains nearly constant) as an indication for a loss of winter time ozone destruction in clouds. We found that between the amplitude (summer/winter ratio) and the station elevation above sea level a strong correlation exists. However, the corresponding ratio for Mt. Brocken exceeded the expected one (2.3) nearly by a factor of two in 1992. Till 1996 we observed a decreasing amplitude, now in agreement with the „normal" correlation. Considering parallel changing cloud chemistry parameters (e.g. acidity) we present the hypothesis of loosing ozone removal capacity in the winter season. Moreover, we would like to stimulate the discussion on the importance of heterogeneous sink processes for the mesoscale oxidant budget.
K. Acker, W. Wieprecht, D. Möller, G. Mauersberger, S. Naumann and A. Oestreich (1995) Naturwiss. 82, 86-89

CHARACTERIZATION OF AEROSOL PROPERTIES AND DIRECT RADIATIVE FORCING AT AN ANTHROPOGENICALLY PERTURBED CONTINENTAL SITE

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Ambient aerosol particles affect the radiation balance of the Earth directly or indirectly. This can have an effect on climate but also on tropospheric ozone chemistry and vertical distribution as more radiation can be available above than below the aerosol layer. In addition, secondary particulate pollutants are formed by the same precursors as ozone. Therefore, ozone chemistry and aerosol particle chemistry and optical properties are interrelated. Measurements of optical, chemical and physical properties of ambient aerosol particles were obtained during 1995 at a sampling station, at Bondville (N 40o 03' 12" N, 88o 22' 19" W), Illinois, USA, a site representative of a continental anthropogenically perturbed environment. The inorganic water soluble aerosol comprised half of the total gravimetric mass and it was dominated by ammonium and sulfate ions. Organic and elemental carbon constituted the rest of the gravimetric mass. The upscatter fraction and the hygroscopic growth factor as functions of wavelength of light were quantified from the measurements. The quantified parameters were used in a box model to estimate the difference in the clear-sky shortwave flux at the top of the atmosphere caused by the aerosol particles in the region.

NUMERICAL INVESTIGATION OF THE INFLUENCE OF BIOGENIC EMISSIONS ON OZONE IN SAXONY (GERMANY)

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Biogenic emissions of e.g. terpene and isoprene (emitted by trees, for example) and NO (as a product of microbial degradation) modify the ozone concentrations close to the ground especially in rural areas. These substances are extremely reactive and contribute considerably to the oxidation capacity of the troposphere. This kind of emissions can only be influenced to a certain degree by human beings.
The model system METRAS - MUSCAT - Euro-RADM is used to investigate the impact of biogenic emissions on the ozone concentrations under summer conditions. The model was applied to the area of Saxony (Germany) where major rural areas can be found. Included is a sensitivity study about the influence of the emissions from rape on the ozone production in the model domain because rape is one of the major crops grown in Saxony.

PRODUCTION AND EMISSION OF ACETALDEHYDE IN TREES

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The photolytic and oxidative destruction of the tropospheric trace gas acetaldehyde results in a net production of ozone. Acetaldehyde is either directly emitted into the atmosphere or is produced there by oxidation of hydrocarbons. Besides industry, the combustion of fuels and biomass burning are considered as major sources of atmospheric acetaldehyde. Although acetaldehyde is known to be synthesised in the biosphere by a wide range of organisms, its emission from biogenic sources into the atmosphere is poorly understood. In the present studies we examined the metabolic origin of acetaldehyde and its emission by the leaves of young poplar trees. Treatments which increased the ethanol concentration of the xylem sap significantly enhanced acetaldehyde emission by the leaves. Since plants fed with ^{14}C-radio-labelled ethanol emitted labelled acetaldehyde by the leaves it is assumed that acetaldehyde is synthesised through oxidation of ethanol xylem derived by leaf alcohol dehydrogenase. Further labelling experiments suggested that ethanol delivered to the leaves is produced in anaerobic zones of the roots by fermentation processes. Flooding the root system caused anoxic conditions in the rhizosphere and resulted in significantly increased ethanol concentrations in the xylem sap. From these results it is hypothesised that acetaldehyde emitted by the leaves of plants originates from xylem transported ethanol which is synthesised during alcoholic fermentation in the roots.

PHOTOCHEMICAL SMOG IN SANTIAGO DE CHILE - RELATIONSHIPS BETWEEN PRECURSORS NO_X, CO, NMHC AND SECONDARY COMPOUNDS OZONE AND PAN

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In November and December 1996 a campaign called PHOTOCHEMICAL CAMPAIGN took place in Santiago de Chile covering a range of simultaneous measurements of meteorological parameters and air chemical compounds including ozone, CO, NO_x, PAN and on-line NMHC.
Strong emissions of primary pollutants during stagnant weather conditions lead to a rapid increase of CO, NO_x, and NMHC in Santiago. Intensive global radiation during daytime, temperatures between 30°C-35°C and the specific orographic situation of Santiago de Chile close to the highest mountain ranges of the Andes that leads to the development of a very persisting valley-mountain-breeze system favours the formation of photooxidants through effective consumption of primary pollutants in the course of the day. Similar conditions may be found in the Mediterranean Area as was shown during MEDCAPHOT-TRACE. However, the case of Santiago shows a unique example to study the evolution of photochemical smog since episodes occur almost daily and are pronounced, with high PAN values, a specific indicator for anthropogenic driven photochemistry.

OZONE INJURY SPATIAL PATTERN IN ALEPPO PINE AND AIR POLLUTION DYNAMICS IN THE MEDITERRANEAN.

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Interdisciplinary studies, combining the evaluation of effects with the tracking of photooxidants (i.e. ozone) and the meso-meteorological interpretation of the data, have been carried out in eastern Spain since 1994. Mesoscale circulations are very important from the point of view of how and where forest ecosystems are affected by point sources and regional air pollution in the Mediterranean area. The recirculation processes in the Mediterranean strongly influence the ozone daily and spatial patterns. First results of these field surveys show that during 1994, 95 and 96, visual ozone injury (chlorotic mottle) in *Pinus halepensis* was well correlated with the penetration of the sea breeze in coastal valleys of Castellón. AOT40 calculated for the monitoring stations located in the Mijares valley show values under the threshold (10.000 ppb.h) near the city of Castellón, whereas in the other stations inland along the valley the threshold is surpassed all summer long until September-October. Ozone seems to be able to affect Aleppo pine under different climatic conditions. And chlorotic mottle can be used as a field indicator of the degree of ozone effects, even in different climatic conditions. Finally, a higher percentage of chlorotic mottle is present in needles of *Pinus halepensis* from the valley localities closer to the seashore, where the seabreeze entrance is more frequent during the whole year. This mechanism brings high ozone levels inland from the coast.

DAILY OZONE PATTERNS AND AOT40 INDEX IN EAST COAST OF THE IBERIAN PENINSULA

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The complexity of air mass dynamics in the Mediterranean has already been quite well documented in several EU research projects conducted in the area since 1989 (MECAPIP, RECAPMA and SECAP).It is clear now that the recirculation processes involved, in which new emissions (NOx and other precursors) are incorporated, strongly influence the daily and spatial ozone patterns in the Mediterranean. In this sense, the results from the Valencian Community air quality network, show that within a natural pathway of air mass transport (e.g. a valley) three different O3 diurnal patterns are clearly distinguished: high elevation, medium and coastal sites. High altitude sites are characterised by maintaining an almost constant high O3 level throughout the day (no diurnal cycle). Low altitude sites have maximum levels coinciding with daylight hours and close to zero O3 levels at night (diurnal cycle). At the medium altitude sites the maximum values occur in the daylight hours; however, O3 levels never drop to zero. These different patterns change in the narrow range of 50 to 60 km (smaller than the minimum EMEP model grid of 50 or 150km), which implies a huge spatial variability in the area. AOT40 index for 3 and 6 months are calculated as a running value through the year and compared for the different O3 patterns. Also, several daylight windows have been used in the AOT40 calculations in order to check the sensibility of the index to the time window choice and to the different ozone daily patterns compared to the AOT40 calculated for real day hours (radiation>50w/m2). It has been concluded that all daytime windows, produce overestimations in diurnal cycle sites and underestimations in non diurnal cycle sites of the AOT40 values when they are compared with the real day time hours (radiation>50w/m2).

Tropospheric ozone and Sulpher dioxide in Cairo atmosphere.

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Surface ozone (O3) and sulpher dioxide (SO2) gas were evaluated in the atmosphere of a residential site at Cairo (30.05 N , 31.17 S) from October 1994 to March 1995. This work discuss sources of ozone and sulpher dioxide in the atmosphere particularly with regard to the relative contributions of fluxes from the stratosphere and that created due to photochemical reactions. Hourly concentration of SO2 shows that the maximum value was at 9 am. associated with traffic emissions which is a major source of SO2 in this period and residential area. The diurnal variation of ozone concentration exhibits it peak values in the afternoon which indicate a strong contribution of photochemical smog.

THE ROLE OF ANTHROPOGENIC AND BIOGENIC EMISSIONS ON TROPOSPHERIC OZONE FORMATION OVER GREECE

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In this study an attempt was made to examine the response of a grid-based photochemical model on the simulated tropospheric ozone levels for various emission patterns. More precisely, the role of the biogenic emissions to the tropospheric ozone formation over areas with significant anthropogenic sources is investigated. The area of interest is the SE part of the Greek Peninsula where there are various types of anthropogenic pollutant sources including large urban areas, major industrial installations, power plants, main traffic routes and it is covered by various types of forests in a large extent.

For this purpose ozone air quality simulations were performed using the combined system of the atmospheric model RAMS and the photochemical model UAM. Simulations were performed using various emissions scenarios with and without the implementation of biogenic inventories.

Solar effective UV irradiance at height levels form the surface to the tropopause

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Measurements of the solar biologically effective UV radiation were carried out during the period from 7 to 14 June 1997 by using a radiometer flown on a Falcon aircraft, at several altitude levels, from sea level up to 13 Km. The results showed that an increase occurs of about 8-13% per kilometer throughout the troposphere in the biologically effective UV radiation.This increase has been compared with the burden ozone content at each height level as it was derived from concurrent ozone measurements obtained from ozonesonde ascents. This comparison showed a strong correlation between the biological effective UV radiation and the total ozone content above the UV measurement height level.

On the role of the Lower-Stratospheric Circulation to the Vertical Ozone Structure

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The examination of the role of the lower stratospheric circulation to the vertical ozone distribution, is attempted by using the vertical ozone profiles collected by balloon-borne sondes released at Athens, Greece (38 N, 24 E), throughout the period 1989-1997. The most pronounced features of the ozone structure, such as lamination phenomenon, minimum of ozone partial pressure at the height region of 14-17 km and ozone minima at the height region of 20-25 km, have been used in order to create groups of relevant profiles. The occurrence of the above mentioned features, correlated with the circulation pattern, leads to the following preliminary results: a) Laminated features are associated with the north-northwest circulation in the lower stratosphere; b) The lower stratosphere?s characteristic ozone minimum is related to the influence of the subtropical jet stream circulation; and c) The observed ozone depletion at the height region of 20-25 km, is characterized by the movement of the polar vortex to the mid-latitudes, resulting more intense north-western circulation above our experimental site.

ON THE ROLE OF SEA SALT PARTICLES IN POLLUTED MARINE AREAS

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The reactions of gaseous N2O5 and ClNO3 with Solid NaCl, Solid NaBr and mixed NaCl-NaBr are increasingly recognised as significant in polluted areas. In this study an attempt has been made to examine additional reduction processes by using the interconnection of entropy and enthalpy for various processes with well known macroscopic properties of the bulk solid at temperatures300K.

VERTICAL OZONE DISTRIBUTION IN THE TROPOSPHERE AT ATHENS GREECE

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Measurements of vertical ozone distribution of the tropospheric ozone over Athens Greece (38 N, 24 E) during the 1995-96 winter period are correlated with the prevailled meteorological conditions. In particular, ozone concentration at the troposphere at Athens as deduced from ozonesounding observations are discussed with regard to the transport at the 700 hPa level. Analusis results show that the free tropospheric ozone concentration is affected by the general circulation pattern, with variations of the order of 10%.

THE ROLE OF WATER VAPOUR ON THE TROPOSPHERIC OZONE DEPLETION

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A plaussible relationship between the fluctuations of Ozone concentration and the water vapour mixing ratio at the Athens troposphere is detected. To reach this target, measurements of both, ozone concentration and relative humidity are used by utilising the five years record (1993-1997) of ozonesoundings regurarly performed at Athens Ozone Station. Furthermore, the invention of a theoretically deduced mechanism is finally attempted to illustrate the experimentally derived relationship.

CLOUD IMPACT ON SURFACE ULTRAVIOLET RADIATION

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One can suppose that surface UV-irradiance may increase slightly under condition of small cloud amount comparing the case clear sky by reason of reflection and scattering of solar radiation from cloud sides. Then, with growing of cloud amount, surface UV-irradiance decrease. The elaboration of three-years set of data of UV-irradiance measured in St.-Petersburg and Athens is undertaken. The influence of solar zenith angle is taken into account. The dependence of surface UV-irradiance on cloud amount and solar zenith angle is presented.

SURFACE OZONE MEASUREMENTS OVER ATHENS BASED ON THE HISTORICAL DATA FOR THE PERIOD 1901-1940

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A unique data base for surface ozone concentrations over Athens Greece, for the period 1901-1940 is available based on observations made at the National Observatory of Athens, by using DeJames colometric papers. There-evaluation of these data denotes that during the first half of the 20th century, surface ozone concentrations varried around 20 ppb, with maximum values occured during late spring-early summer period and minimum values during late Autumn period.

ST15 Atmospheric ozone (joint with OA)

Convener: Hirschberg, M.-M.

05 Ozone as a Climate Gas

Convener: Varotsos, C.

THE EFFECT OF A MORE REALISTIC OZONE DISTRIBUTION ON CLIMATE SIMULATION WITH A GCM

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So far, the background ozone field used for climate simulations with the ECHAM GCM in Hamburg, was derived from an analytical formula which calculated ozone profiles as a function of total ozone and ozone peak height distribution. To assess how a more realistic ozone distribution might influence the simulated climate, a new zonal monthly mean ozone climatology, based entirely on ozonesonde and satellite observations over the target period 1980-1991, was built into ECHAM and run in an uncoupled mode using prescribed sea surface temperatures. The results are compared to those of a similar control run using the previous ozone climatology. A short summary of the new ozone climatology characteristics and its differences with regard to the previous climatology will be presented, followed by an overview of the main results from the two control runs. It is found that the systematically lower ozone values of the new climatology around the tropopause leads to lower temperatures here, accompanied by increased convection and high cloudiness epecially in the Tropics. The influence of the ozone hole over Antarctica - in contrast with the ozone spring maximum of the previous climatology - is mainly a cooling and intensification of the polar vortex in October, but also in November when the ozone hole has almost recovered. The results from the control runs are compared with re-analyses from ECMWF.

OZONE: RADIATIVE FORCING AND CLIMATE SENSITIVITY

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We present a series of general circulation model experiments with prescribed ozone perturbations in different vertical intervals. Both the radiative forcing on the tropopause and the near-surface temperature are used as diagnostic quantities. The climate sensitivity, i.e. the surface warming per unit radiative forcing, and its dependence of the hight of the ozone perturbation are calculated. The model used is Arpege and all experiments are integrated under perpetual January conditions.
A large value of the climate sensitivity and a corresponding large positive feedback are found for perturbations of the upper stratosphere. This should be compared to the relative weak positive feedbacks found both for ozone perturbations in the lower stratosphere and in the troposphere and in a doubled CO_2 experiment. The climate change is analysed primarily by studying the changes in the energy balance at the surface and the related changes in the hydrological cycle. The influence on the climate sensitivity of the definition of the tropopause level as well as of the definition of the radiative forcing is investigated.

IMPACT OF ANTHROPOGENIC ACTIVITIES ON TROPOSPHERIC OZONE

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The budget of ozone and its evolution resulting from anthropogenic activities are simulated with a global three-dimensional chemical-transport-model, called MOZART (Model of OZone And Related chemical Tracers). MOZART is developed in the framework of the NCAR CCM2 and considers a comprehensive tropospheric chemistry including non-methane hydrocarbons. It calculates the distribution of 56 chemical species with a resolution of 2.8 degrees in both latitude and longitude, 25 levels on the vertical (from the surface to the upper stratosphere) and a time step of 20 min.
In this paper, we present the changes in tropospheric ozone and its precursors (CH_4, NMHCs, CO, NO_x) since the pre-indutrial period. The ozone change at the surface exhibits a maximum increase at mid-latitudes in the northern hemisphere reaching more than 40–50 ppbv over Europe and the southeastern US during summer. The possible evolution of ozone in year 2050 is also calculated with the model based on estimated future scenarios. The impact of the present-day and future aircraft fleet on nitrogen species and ozone is also included in our simulations. The impact of these past and future ozone changes (including aircraft emissions) on the radiative forcing of the climate system are discussed. The seasonal and geographical distributions of the radiative forcings are illustrated.

LONGITUDINAL DIFFERENCES IN SEASONAL OZONE CHANGES OVER NORTHERN MIDLATITUDES

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Time series of total ozone seasonal (winter-spring and summer) means from European Dobson stations and those from the United States and Canada have been analysed. For each of the considered stations, the mean values for both seasons are positively correlated and their differences decrease. The correlation coefficient values are significantly greater for the Northern American stations than for the European stations, indicating a longitudinal dependence of seasonal variation of total ozone. Its correspondence with seasonal variation of the Brewer-Dobson circulation cell is suggested. Taking into account the fact that the winter-spring and summer total ozone means are well correlated over North America, it is possible to use in this region the winter-spring mean value as a predictor to infer the summer mean value. This may be useful in making an early estimate of potentially excessive solar UV radiation during the summer months.

THE TROPOSPHERIC CARBON MONOXIDE DISTRIBUTION IN THE NORTHERN TEMPERATE BELT AS THE 2-D MODEL CALCULATION RESULT

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The carbon monoxide and ozone with other minor constituents concentration in the 0-16-km layer and in the 30°-60° N belt is calculated by the 2-D (height-longitude) nonstationary photochemical model with climatic zonal and vertical fixed transport. The concentrations of 32 atmospheric species are calculated, about 170 atmospheric reactions among oxygen, hydrogen, nitrogen, carbon, chlorine and bromine compounds during diurnal course are considered.
The geographical inhomogenity of the surface carbon monoxide releases and their seasonal variability are accounted. The climatic data of tropospheric humidity and rains from "The NCEP/NCAR 40-year reanalysis project" are used. The distinction between water vapor content values over land and ocean determines generally nonhomogeneous distribution of hydroxyl radical. The carbon monoxide spatial inhomogenity is due to the inhomogenity of both its sources and hydroxyl as the main carbon monoxide destroyer. The model results are discussed and compared with observations.

TRENDS IN TROPOSPERIC AND LOWER STRATOSPHERIC OZONE IN EUROPEAN ARCTIC

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Ozone sonde time series from Sodankylä Observatory of the Finnish Meteorological Observatory is put through a statistical analysis of long term changes from 1988 to 1997. Careful attention is paid on data quality, concentrating on pre-flight calibration records and comparative column data. Sodankylä data form the longest continuous ozone sonde series in the European Arctic, at present there are 640 ozone soundings in the series. Finnish data indicate ozone decrease in the troposphere of the order of 1..3% per year since late 1980's. Results of statistical analysis are compared to other studies of ozone trends.

PRESENT–DAY AND FUTURE IMPACT OF AIRCRAFT INDUCED OZONE CHANGES

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Aircraft induced NO_x emissions lead to significant modifications of the atmospheric ozone concentration. Hence, an additional radiative forcing is provided to the climate system. It has been shown that the resulting climate impact is also significant, even for present–day subsonic air traffic. This is demonstrated by equilibrium climate change simulations with a comprehensive 3D model of the atmosphere ocean system.
However, it appears that the relation between the radiative forcing and the climate change (in terms of surface temperature change) in the ozone sensitivity experiments is not as straightforward as it is usually found in greenhouse gas experiments. Even for present–day aircraft conditions, for which the ozone perturbation is largely restricted to the middle and upper troposphere, a considerably nonlinear dependence of the global mean temperature response from radiative forcing can be found.
For future aircraft scenarios (assuming the existence of a commercial stratospheric air–fleet) , for which the lower stratosphere ozone distribution is also affected, the radiative forcing seems to be a bad predictor of climate change.

LOWER STRATOSPHERIC TEMPERATURES AND THEIR RELATIONSHIP WITH OZONE TRENDS

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Subjectively analysed data from the Freie Universität Berlin (FUB) are used to illustrate the changes in the thermal structure of the lower–middle stratosphere over the past four decades. Annual mean temperatures in the Northern Hemisphere reveal a pronounced cooling, which is not well described by a linear trend. The cooling has accelerated since 1993, following a warming caused by the radiative effects of volcanic aerosols from the Mt. Pinatubo eruption in 1991. Lower stratospheric temperatures from the Microwave Sounding Unit, available since 1979, give independent confirmation of this cooling. There is a clear connection between the recent accelerated temperature decrease and total ozone changes. This is shown to be broadly consistent with the reduced heating in the lower stratosphere and has implications for the radiative energy input into the upper troposphere.
Some of the possible feedbacks will be discussed. Closer examination of the temporal and spatial structure of the cooling reveals an apparent trend in the springtime, which allows the possibility of increased ozone destruction resulting from heterogeneous chemical processes. Some attempts to separate the causality of the temperature and ozone decreases will be presented; effects on the radiative forcing of the troposphere in Northern Spring will be discussed.

EXPERIMENTS EMPLOYING OZONE CHANGES IN A GENERAL CIRCULATION MODEL

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The effect of ozone change on the climate is investigated using the Intermediate General Circulation Model (IGCM) developed at Reading. Several ozone change experiments have been performed, ranging from simple idealised scenarios to rather more realistic ozone perturbations. The simpler scenarios investigate the effect of idealised perturbations to the ozone profile at various different altitudes, whilst the more realistic experiments include (a) employing climatological ozone adjusted to fit TOMS observations and (b) employing observations of ozone change throughout the depth of the troposphere and stratosphere. In each case the effect on the stratospheric circulation and temperature trends, both in the stratosphere and at the surface, is examined.

LÉVY FLIGHTS BY PHOTONS IN CLOUDY SKIES ? IMPLICATIONS FOR THE SW-HEATING OF TROPOSPHERIC OZONE

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Recently theoretical and observational studies have highlighted that under 'real' inhomogeneous or fractal cloudy sky conditions the photon geometrical paths are α-stable Lévy-distributed, which is different than implicitly or explicitly assumed in non-statistical plane parallel homogeneous radiative transfer (RT) models. Since for Lévy type transport statistics, the probability density functions of optical paths (PDF-OP) is different than modelled using non-statistical RT-models, the SW-solar radiation absorption is likely to be altered. In particular, Lévy type transport statistics favour shorter and extremely long geometrical paths at the cost of medium long geometrical paths. This is an intermittency effect, characteristic for transport processes in turbulent media. In consequence of the L'evy type PDF-OP occurring in fractal clouds, the relative contributions of the strong and weak SW-absorbers to the total atmospheric SW-absorption is altered to the ones calculated using conventional RT-models.
Here observational evidence of Lévy transport statistic under cloudy sky conditions is given, and the consequence for the SW-absorption of a weak absorber - tropospheric ozone in the visible wavlength range - is discussed.

CHANGING DISTRIBUTION OF TROPOSPHERIC O_3 AND ITS RADIATIVE FORCING OF CLIMATE: PAST, PRESENT, AND FUTURE

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To assess the possible climate effects of anthropogenically enhanced O_3 in the troposphere, it is essential to distinguish the contributions by natural and anthropogenic processes to the O_3 distribution. With a coupled chemistry - general circulation model (ECHAM4), we calculate the contributions to tropospheric O_3 levels by stratosphere-troposphere exchange (STE) and by photochemical production in the troposphere for pre-industrial, present-day and future (IS92a) emission scenarios. The model simulates background tropospheric CH_4-CO-NO_x-HO_x photochemistry, emissions of CO and NO, and wet and dry deposition. The simulated present-day seasonality of surface O_3 compares well with observations. Stratospheric O_3 contributes significantly to the seasonality of surface O_3, especially in the extratropical SH and in relatively clean areas in the NH. We calculate an annually average tropospheric O_3 burden of 190, 270, and 332 Tg O_3 for the pre-industrial, present-day, and future scenarios, respectively. The contribution of O_3 from stratospheric origin is about 110 Tg and does not change significantly, so the calculated increase of O_3 is associated with photochemical production resulting from anthropogenic emissions of O_3 precursors. The O_3 increase maximizes in the free troposphere where O_3 lifetimes are relatively long compared to the boundary layer, and the climate effect is relatively strong. The calculated radiative forcing at the tropopauze is 0.38 W m^{-2} for the present-day scenario and 0.69 W m^{-2} for the future scenario.

THE TIME EVOLUTION OF TROPOSPHERIC OZONE RADIATIVE FORCING

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The UK Meteorological Office off-line chemistry-transport model (STOCHEM) has been used to perform 3-D simulations of the atmospheric composition at various times: 1860, 1950, 1970, 1990, 2015, and 2050. These simulations were carried out using best estimates of emissions and using present day meteorological fields from the Hadley Centre AGCM. The model includes the chemistry and photochemistry of 70 species, including CH_4, NO_x, CO and 10 NMHCs, including isoprene, and dry and wet deposition. The model took part in the GIM model inter-comparison, and produced a reasonable simulation of present-day tropospheric O_3. Tropospheric O_3 changes since 1860 from these model simulations have been inserted into a radiation code, to calculate the time evolution of the radiative forcing due to increases in tropospheric O_3. Aircraft NO_x emissions are shown to have a significant impact on upper tropospheric O_3 and radiative forcing. Further simulations, using a $2xCO_2$ meteorology, suggest a large negative feedback of the climate on the O_3 change, due to increased temperatures and humidities, and changes in the circulation.

ST16 Stratosphere-troposphere-exchange (co-sponsored by OA)

Convener: Wirth, V.
Co-Convener: Haynes, P.H.

CORRECTION FOR PHASE ERRORS IN LAGRANGIAN MODELLING OF TRACER FILAMENTS

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The main mechanism of mixing of chemical species in the stratosphere is thought to be a combination of horizontal advection and vertical shear. The result of this mixing is, generally, a filamented structure of the tracer fields, both horizontally and vertically. This structure has been confirmed, for example, by various *in situ* aircraft measurements and balloon soundings. Recently, efficient Lagrangian based modelling tools have been developed to asses the fine-scale structure in the tracer fields. However, these tools are thought to be of limited importance for the prediction of measurements because they often show poor correlation between reconstructed and measured tracer concentration.
We show that the main sources of this poor correlation are phase errors in the advected structures and errors in the determination of the reconstructed tracer field at the exact time of measurement. This is proven by correcting for these errors through a process of optimization (under certain constraints) of the correlation between measured and reconstructed tracer concentration and by explicitly taking into account the exact time of measurement. After these corrections the linear correlation between the measurement and the reconstruction may be higher than 90%.

FINE STRUCTURE OF WATER VAPOUR TRANSPORT AT THE POLAR VORTEX

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The fine structure of water vapour transport at the edge of the polar vortex in northern winter has been investigated with a 3-dimensional model. The experiments were performed with a primitive equation mechanistic model. It was forced using observed 200hPa geopotential height fields for typical dynamical situations in wintertime. It has been run with coupled chemistry, using an accurate semi-Lagrangian transport scheme at a horizontal resolution of 1.4° x 1.4° and a vertical resolution of 1.4km. The fine structure of the water vapour fields near the polar vortex edge are examined. The contributions of chemical and dynamical processes are investigated.

LAGRANGIAN CLIMATOLOGY OF A SIMPLIFIED GENERAL CIRCULATION MODEL

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We investigate the Lagrangian climatology of a Simplified General Circulation Model. The model integrates directly the primitive equations for the atmospheric fluid on a sphere. It make the assumption of dry air and consider no orography. Simple linear parametrizations are used to describe dissipative and radiative processes.
Lagrangian tracers have been seeded on isentropic surfaces in the Eulerian field and their trajectories have been integrated in time, both using an isentropic 2D approximation and using full 3D advection.
We discuss the presence of barriers to transport and the possibilities of interemispheric and troposphere-stratosphere exchanges. Measure of the absolute meridional dispersion, spectra and histograms of tracers velocity allow to investigate the different dynamic Lagrangian behaviours for the regions separated by barriers.
To explore the role of seasonal forcing, we compare simulations with annual cycle with perennial spring runs. From the comparison of Lagrangian velocities histograms arises that the application of seasonal forcing does not change significantly the mean dynamics simulated by the model. This result is confirmed by the evaluation of Lagrangian velocities power spectra.

LITHOSPHERIC STRUCTURE BENEATH THE SOUTHERN FRENCH ALPS INFERRED BY BROAD-BAND ANALYSIS.

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We present the preliminary results of a field experiment made as part of the GéoFrance 3D Alpes programme. During this passive seismological experiment, broad-band stations (CMG40 and CMG3) were set up during periods of 3-4 months at different sites to complete the recently installed TGRS and ROSALP broad-band networks in the french Alps. We analyse teleseismic P-waves and their coda in order to constrain the lithospheric structure beneath the western Alps. We take advantage of the three components to compute Receiver Function isolating by the way the local Earth structure response beneath each station. The functions are inverted (in shape and amplitude) to recover the vertical variation of the waves velocities up to 50 km. Furthermore, we are looking for a model below 50 km by stacking data from different events to increase the signal-to-noise ratio of the 450- and 650 km discontinuities. The short distance between the station gives us a good control on the lateral variations of the lithospheric structure which we try to relate to the geodynamical context of the region.

A CLIMATOLOGY OF STRATOSPHERE - TROPOSPHERE OZONE EXCHANGE FOR THE ATLANTIC - EUROPEAN SECTOR

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Quantification of stratosphere-troposphere transport is fundamental to the study and modelling of tropospheric and stratospheric chemistry. Here the annual distribution of upward and downward ozone flux across the tropopause is estimated in the 40°-60° latitude band covering the Atlantic and Europe sectors for the period May 95-May 96. The study is based upon aircraft measurements (NOXAR project) and a pseudo-Lagrangian trajectory calculation model using ECMWF analysed data. The focus is on strong exchange events involving trajectories directly crossing the 2PVU-tropopause, and ozone mass conservation along trajectories is assumed. This method delivers estimates of the means of the: exchange probabilities; ozone concentration of the exchanged masses; origin and destination pressure levels of the exchanged parcels. The mean O_3 vol. mixing ratios of exchanged masses possess a nice structure and the mean exchange probabilities appear to be qualitatively well correlated with a yearly averaged tropopause cut-off probability calculated with ECMWF data.

ISENTROPIC AND THREE-DIMENSIONAL TRAJECTORIES NEAR THE TROPOPAUSE

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The effect of including three dimensional motion near the tropopause onstratosphere troposphere exchange is investigated using isentropic and three dimensional trajectories. Recent work has suggested that the differences between two and three dimensional motion may be important on a seasonal timescale (Eluskiewicz, Geophysical Research Letters 23,1996). Here we show that where diabatic processes take parcels through the region of large vertical shear near the mid-latitude jet, the effect on the shape of small scale structures, such as tropopause folds, is significant even on timescales of a few days. This suggests that a proper treatment of stratosphere troposphere exchange mechanisms near to the tropopause requires a full three-dimensional treatment.

MIXING OF TROPOSPHERIC AIR INTO THE MID-LATITUDE STRATOSPHERE AND ITS ROLE IN ATMOSPHERIC CHEMISTRY

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During recent years high resolution in-situ observations of a variety of trace gases have been carried out at northern mid-latitudes in the tropopause region in the framework of the Stratosphere Tropopshere Experiment by Aircraft Measurements (STREAM) project. Trace gas and particle distributions in the lowermost stratosphere will be discussed. The dependence of these distributions on season will be shown, including evidence of significant mixing from tropospheric air into the lowermost stratosphere. In addition, implications of these mixing processes for atmospheric chemistry will be demonstrated with results from a three-dimensional Chemistry-Transport Model.

Heterogeneous chemistry in the tropopause region

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This presentation elaborates on the possibility of chlorine activating heterogeneous chemistry in the tropopause region occurring on cirrus cloud crystals, supercooled droplets, layers of increased numbers of small aerosol particles, and solution droplets of the upper tropospheric background aerosol. The high water vapor content, low temperatures, and slow photochemical recovery times near the tropopause make this region susceptible to heterogeneous processing, just as the extreme cold temperatures over the poles do for dryer air at higher altitudes. A detailed 2-D model study by Solomon et al., 1997, revealed that heterogeneous chemistry on the aerosol of the tropopause region could make a significant contribution to the ozone depletion in northern mid-latitudes. Input for these model calculations are climatological SAGE II satellite observations of cirrus cloud optical depths and cloud occurrence frequencies from 1988 and 1989, i.e., years of relative volcanic quiescence. Because of variations in observed cloud occurrence frequency and in photochemical and dynamical timescales, the presence of cirrus clouds likely has its largest effect on ozone near the northern hemispheric midlatitude tropopause. There the low background ClO mixing ratios could be enhanced by heterogeneous reactions by factors of 30, according to the model results. Since the reformation of HCl is a very slow process in the lowermost stratosphere, the relaxation of ClO to the clear sky background abundances can take hours to days depending on latitude and season. Thus, elevated ClO might persist longer than the cloud event itself. Due to the lack of chlorine nitrate, HCl, and ClO observations the discussed processes have to be considered as hypothetical. However, consideration of upper tropospheric heterogeneous chemistry might contribute to explain the shape of the vertical ozone depletion profile.

MICROWAVE LIMB-SOUNDING OF WATER VAPOR IN THE TROPOPAUSE REGION

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Microwave limb-sounding is a very promising technique for global measurements of water vapor in the lower stratosphere and upper troposphere. However, the interpretation of data from the tropopause region is not as easy as at higher altitudes. Firstly, the linear approximation is not valid at low tangent altitudes, due to the high water vapor absorption. Secondly, cirrus clouds have an impact on the measurements, which is difficult to model.
We are presenting a case study based on data taken by the Millimeterwave Atmospheric Sounder (MAS) instrument during the ATLAS 1 Space Shuttle mission in March 1992. Care has been taken to separate data with and without cirrus cloud contamination. The cloud information was taken from the Meteosat Cloud Analysis (CLA) data product. The MAS data is compared to the GEOS-1 Multiyear Assimilation Data Set, issued by the Data Assimilation Office at Goddard Space Flight Center. The GEOS data set contains global water vapor fields, four times daily, up to 20 hPa. The comparison indicates that the GEOS data is significantly too high at altitudes above the tropopause.
A comparison of the MAS data with radiosonde measurements available from the UKMO is also presented.

EXPERIMENTAL EVIDENCE FOR THE EXISTENCE OF A VERY LOWERMOST STRATOSPHERE

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The gross transport of tropospheric air into the stratosphere occurs in the tropics through the Brewer-Dobson circulation. Nevertheless, there are also experimental and theoretical findings for the direct impact of the troposphere on the extratropical, lowermost stratosphere in the course of near-tropopause phenomena such as penetrative cumulus convection or small-scale mixing associated with upper level fronts and cyclones. However, little is known on the penetration depth of this direct impact and its geographical variations nor on the persistence of these tropospheric imprints in the stratosphere.
In this paper, we will examine tracer-tracer-correlations from recent measurements in the extratropical tropopause region. These correlations strongly indicate the existence of a direct troposhere-to-stratosphere transport establishing an exchange layer just above the tropopause. The depth of this very lowermost stratosphere varies considerably as a function of the geographical location and exhibits a maximum in the vicinity of the mid-latitude jet stream.

ON THE USE OF THE RDF-TECHNIQUE FOR THE INTERPRETATION OF HIGH-RESOLUTION TRACER MEASUREMENTS IN THE TROPOPAUSE REGION: A CASE STUDY

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Subsynoptic and mesoscale flow features at tropopause levels pre-dominantly occur during stratospheric intrusions. These features are likely to result from the formation of filaments of air masses being either rolled-up or elongated in the presence of a background wind shear. With the recent introduction of model techniques like reverse-domain-filling (RDF) there has been an enormous progress in the modelling of filamentary structures observed by tracer measurements.
In this paper, we will discuss the correspondence between experimental data and the results produced by the RDF-technique on the basis of a detailed case study. For the specific case, rich and coherent subsynoptic mesoscale features has been observed by satellite-borne water vapour images and airborne tracer measurements in the polar frontal region during a strong stratospheric intrusion. It is shown that the potential vorticity reconstructed via the RDF-method reveals filamentary structures that correlates with features seen by tracer measurements not only regarding positioning but also regarding amplitude. Sensitivity studies were carried out to demonstrate the possibilities for the optimization of the RDF-method and the limitations of its applicability.

STRATOSPHERE-TROPOSPHERE EXCHANGES ACROSS THE POTENTIAL VORTICITY BARRIER OF THE SUBTROPICAL JET AS SEEN WITH MOZAIC-OZONE MEASUREMENTS

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The existence and the efficiency of the subtropical potential vorticity (PV) barrier inhibiting the stratosphere-troposphere exchanges between the lowermost extratropical stratosphere and the upper equatorial troposphere are investigated using Measurements of OZone by Airbus in-service AIrCraft (MOZAIC). Among the episodes of high ozone content encountered along MOZAIC flight tracks over Central Atlantic, only those having mixing ratio peak values exceeding 100 ppbv are considered. The ozone episodes that have sub-synoptic to synoptic lengths ($\geq$ 100 km) are all located north of 15-20^{0}N, which corresponds to the mean latitude of the dynamical barrier due to the strong isentropic PV gradient on the cyclonic shear side of the subtropical jet core. Inversely, all the ozone episodes having shorter length scales (a few km to 100 km) are located south of the subtropical barrier within the upper equatorial troposphere. These ozone-rich transients carry ozone mixing ratio that are comparable to that of their isentropic layer when embedded in the lowermost extratropical stratosphere. The occurence of so many ozone-rich transients southward of the subtropical barrier and in such an isentropic layer prompts to revisit our ideas on the efficiency of the barrier against isentropic exchanges and small-scale mixing processes.

LIFE CYCLE OF A TROPOPAUSE FOLD.

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This presentation is a diagnostic study of the whole life cycle of a tropopause fold, from the initiation through the tropospheric fossilization. The case study occured in February 1997 during a shared period of two experimental projects: TOASTE-C (Transport of Ozone and Stratosphere-Troposphere Exchanges) and FASTEX (Fronts and Atlantic Storm Tracks Experiment). The reinforcement of the observations on the eastern coasts of the United States and over the Atlantic Ocean for the FASTEX experiment allowed the initiation phase to be well captured over New Foundland (Canada) by the ARPEGE (Météo-France) global scale analysis system. With guidance based on successive diagnoses derived from the 72-h, 48-h and 24-h forecasts of the ARPEGE model, a french research aircaft (ARAT/INSU) equipped with the Airborne Lidar for Tropospheric Ozone (ALTO) has flown south of Ireland and over the Biscay Bay to sample the tropopause fold before its landfall over western Europe. As expected, lidar observations showed a thin mid-tropospheric layer with ozone mixing ratio about 60-80 ppbv. After documenting the tropopause fold life cycle and discussing the ozone observations, the presentation will finish with perspectives to evaluate stratosphere-troposphere exchange in this case.

THE RADIATIVE CONSTRAINT ON TROPOPAUSE HEIGHT

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The height of the tropopause is determined by a combination of radiation and dynamics. It was proposed by Held (1982, J. Atmos. Sci.) that these effects might be decoupled into radiative and dynamical constraints, each relating the height of the tropopause to the tropospheric temperature lapse rate. A simple model based on Held's radiative constraint was tested by Thuburn and Craig (1996, J. Atmos. Sci.) in a number of experiments using a full atmospheric general circulation model (GCM), and found to give good agreement. Further analysis of the simple model shows the radiative constraint to be a consequence of the fact that the lower stratosphere is close to radiative equilibrium, thereby constraining the tropopause temperature. This understanding of the simple model has been verified directly using a more detailed radiative transfer code, and generalised to predict the dependence of tropopause height on shortwave radiative heating and dynamically-driven vertical motions in the lower stratosphere. These predictions were tested against further GCM experiments which varied the apparent momentum source in the stratosphere.

WATER VAPOUR TRANSPORT ASSOCIATED WITH THE ASIAN SUMMER MONSOON

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This study employs ECMWF Re-Analysis data to investigate the water vapour distribution in the upper troposphere. Water vapour is the primary greenhouse gas and understanding the processes which determine its distribution and transport is crucial. Of special interest is the exchange of water vapour across the tropopause. Our study considers how the Asian summer monsoon affects the moisture budget of the upper troposphere and lower stratosphere. We find that the region of the Asian summer monsoon is a significant moisture source for the upper troposphere outside the deep tropics. Monsoon convection moistens the region of upper level monsoon anticyclone which is located close to the tropopause break where isentropes slope from the troposphere into the stratosphere. An isentropic analysis shows that transport from the troposphere into the stratosphere in this region is normally prevented by strong potential vorticity gradients around the tropopause. However, midlatitude synoptic disturbances occasionally interact with the monsoon anticyclone and pull filaments of tropospheric air off the northern flank of monsoon anticyclone. These filaments, characterised by high values of humidity and low values of potential vorticity, can extend far into the extratropical northern stratosphere. Our case study constructs a 3-dimensional picture of the water vapour transport associated with these filaments, and their interannual variability is investigated.

THE DRY LOWERMOST STRATOSPHERE IN THE ARCTIC WINTER: EVIDENCE FOR LOCAL DEHYDRATION

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Measurements of H_2O have been performed during the Polar Stratospheric Aerosol Experiment (POLSTAR) in January/ February 1997 in Kiruna $20°E\,68°N$ in order to investigate possible condensation processes in the tropopause region of the Arctic. Correlations between water vapour and trace gases as N_2O, CO and O_3 will be shown in this paper and compared to those obtained at different latitude and season. A linear correlation between H_2O and e.g. CO was found in the lower stratosphere for most of the flights. During these flights, the relative humidity was about 25% or less in the lower stratosphere. However, deviations from this correlation found on two days indicate evidence for dehydration in the tropopause region: In these special situations the H_2O mixing ratio was close to or above the saturation mixing ratio. This mechanism might be important to explain the dryer lowermost stratosphere in the Arctic winter compared to other locations and seasons.

LIDAR AEROSOL MEASUREMENTS SHOWING THE STRATIFIED STRUCTURE OF THE ANTARCTIC POLAR VORTEX IN THE SPRING OF 1992

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The decay of the Mt. Pinatubo volcanic cloud was monitored from 1991 to 1994 by a ground-based backscatter lidar system implemented at the Antarctic station of Dumont d'Urville (66.4 S, 140 E). During winter and springtime, the location of the station at the periphery of the Antarctic continent allows to sample air inside or outside the vortex within very short periods of time. The aerosols measurements performed in the spring of 1992, a period when the vortex was deformed by planetary waves and slanted with respect to the vertical direction, allow to clearly visualise the stratified structure of the vortex. These observations, analysed in equivalent latitude at various altitude levels will be detailed in the presentation, together with ozone sondes measurements performed in the same conditions. A high resolution PV advection model will also be used to evaluate possible mixing with low latitudes regions in the lower stratosphere.

VOTALP: OBSERVATION AND SIMULATION OF A STRATOSPHERIC INTRUSION EVENT OVER THE ALPS

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The aim of the VOTALP project (Vertical Ozone Transports over the ALPs) is to study the various aspects of the ozone distribution over the Alps.
One major focus of VOTALP is to study the influence of statospheric intrusions on the ozone at the Alpine peak level. The project combines observations at Alpine peaks, LIDAR measurements at Garmisch-Partenkirchen, vertical soundings and model simulations.
For a special episode in May/June 1996 a stratospheric intrusion crossing the Alps has been analysed. The measurements show an increase of ozone at the peaks in combination with low humidity and high Be7 concentrations. This episode has been simulated with the EURAD model. This model system consists of the NCAR MM5 mesoscale meteorological model (version 5) and the EURAD-CTM chemistry transport model. The model simulations have been performed to study the transport of ozone and stratospheric tracers towards the Alps. Special emphasis is laid on the further fate of the air masses which have entered the middle an lower troposhere under anticyclonic conditions with subsidence. Trajectory and budget calculations will be presented as well as a comparison of simulated and observed data.

CASE STUDY OF A CUT-OFF LOW DURING TOASTE-C CAMPAIGN .

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Abstract : The purpose of this work is to evaluate the relative contribution of different processes which can lead to the mixing of stratospheric air initialy contained in a cut-off low into the troposphere. The paper is based on a case-study of a cut-off low that occured during the TOASTE-C campaign in JUNE 1996.

The approach taken is to study the evolution of potential vorticity along trajectories initialised in the low. Ozone measurements by MOZAIC are used to check that the initial and final PV distributions may be compared (i.e. the O3/PV ratio in the stratosphere is similar and the position of PV gradients match those in ozone). Since a decrease of PV along a trajectory can occur through diabatic processes or mixing, 3-D and isentropic 2-D ajectory calculations were compared to ascertain the validity of isentropic assumption.

Having verified this validity, isentropic trajectories were calculated at 310 K and 320 K. Comparisons between ECMWF PV fields and MOZAIC ozone measurements showed that the PV fields on the 14th and on the 22nd of June 1996 were reliable. When comparing PV in the cut-off low on the 14th and on the 22nd, a clear PV decay appears at both levels. Convective erosion seems to be responsible for the mixing at 310 K. At 320 K, the vertical component is less likely to be responsible for the mixing, and a horizontal mixing occuring in the region of the jet seems to be predominant.

RADIATIVE DECAY OF STRATOSPHERIC LAMINAE IN THE TROPOSPHERE

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Sometimes layers of air are observed in the troposphere which are stratospheric in most regards but which are lacking a significant high potential vorticity (PV) signature. It has been suggested that this may be a result of radiation, since radiation affects PV but leaves ozone and humidity unchanged. In this paper, the radiative decay of idealized stratospheric laminae located in a standard midlatitude troposphere is investigated numerically using a realistic radiation scheme. The laminae are characterized by high values of PV with a Gaussian profile in the vertical and corresponding signatures in humidity and ozone. Initially the PV-anomalies decay with a characteristic time scale of a few days, but later the decay slows down considerably. At later times radiative cooling renders the upper part of the laminae convectively unstable. For laminae with finite horizontal extent the change in aspect ratio is studied. The results are compared with those from a simple analytical model, which has been used before in the context of stratospheric filaments.

MERIDIONAL TRANSPORT OF OZONE IN THE LOWER STRATOPHERE AT MIDDLE LATITUDES: LIDAR OBSERVATIONS AND SIMULATION WITH A HIGH RESOLUTION ADVECTION MODEL

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The observed decrease of ozone during the last 15 years in the middle latitude lower stratosphere is still not well understood. One of the possible causes of decrease is the transport of polar air depleted in ozone which occurs in laminae formed at the edge of the wintertime polar vortex. The signature of such filamentation events as well as the signature of subtropical intrusions are clearly visible in the vertical profiles of the ozone Lidar set-up at Observatoire de Haute-Provence (44N, 6E). A high resolution model of advection of potential vorticity on isentropic surfaces has been developed in the preparation to the European THESEO campaign in 1998/99. The model will be presented and the results of a simulation made for the case of January 1997, where a polar filament and a subtroppical intrusion were successively observed by the ozone lidar, will be shown.

QUANTIFICATION OF LOWER STRATOSPHERIC MIXING PROCESSES USING AIRCRAFT DATA

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Quantitative bounds on the strength of lower stratospheric mixing processes, represented by a vertical diffusivity D are estimated from high-resolution tracer data collected in recent aircraft campaigns. A first approach based on identifying small-scale features and requiring that D be sufficiently small that such features can survive suggests that D can be no larger than $10^{-2}m^2s^{-1}$ and is perhaps considerably less. A second approach based on identifying features that are partially mixed implies a value of D of $1.4 \times 10^{-2}m^2s^{-1}$. Comments will be made on the disagreement between these results and those deduced from radar studies which have suggested a value of D of around $2 \times 10^{-1}m^2s^{-1}$. Some implications for observed tracer spectra will also be discussed.

TRANSPORT IN THE LOW LATITUDE TROPOPAUSE REGION AS SIMULATED BY THE UK METEOROLOGICAL OFFICE UNIFIED MODEL

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Two simulations made with the climate version of the UK Meteorological Office Unified Model are presented. It is shown that the model simulation near the tropopause is greatly improved when the number of model levels is increased from 19 to 30. Comparison with Halogen Occultation Experiment (HALOE) water vapour observations shows that the change to 30 model levels not only leads to a better simulation of the zonal mean water vapour distribution, but also improves the simulation of prominent longitudinally varying features. A particularly striking example is the simulation of the region of dry air observed over Indonesia at 100 mb in December - January - February (DJF). These results suggest that the 30 level model version realistically simulates troposphere to stratosphere transport in the tropics. Accordingly, in the second part of this paper we present a more detailed examination of such transport made using idealised model tracers and an off-line trajectory model driven by model winds.

ST16

Analysis of the Seasonal Transport of Ozone and Water Vapor into the Lower Stratosphere

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The composition of the lowermost stratosphere is influenced by both the transport of well aged stratospheric air into the lowermost stratosphere, and the incorporation of fresher air more recently transported through the tropical and subtropical tropopause. Using model analysis, satellite data and chemistry codes the relative importance of these two processes are diagnosed as a function of the time of year in both hemispheres.

THE MERIDIONAL CIRCULATION IN THE LOWERMOST STRATOSPHERE

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The meridional circulation in the extra-tropics may be classified according to the nature of the eddies which account for the necessary angular momentum transports. According to this classification the circulation in the lowermost stratosphere is an extension of the tropospheric circulation associated with baroclinic waves. Analysis of the structure of these waves relative to the tropopause reveals a surprising result. The zonally averaged circulation in the stratosphere is, on those isentropes which intersect the tropopause, an indirect circulation away from the pole towards the equator. That is, if one averages around the entire isentrope one finds a direct circultion but if one restricts attention to the stratospheric part of the circulation one finds an idirect circulation. The consequences for tracer transport will be discussed.

NONHYDROSTATIC NUMERICAL SIMULATIONS AND WIND PROFILERS OBSERVATIONS OF A CUT-OFF LOW EPISODE NEAR THE ALPS

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Strong rainfalls in the Alpine region are often linked to the formation and the stagnation of a cut-off low (COL) near the mountain ridge. In the Mesoscale Alpine Programme (Binder et al., 1995), our concern is to study how the Alps influence the different stages of the life cycle of a COL, and how in return, the COL modify the orographic effects. The available experimental system consists in a meso-scale model and a wind-profilers network. The nonhydrostatic model Meso-NH has a complete package of physical parameterizations and can be coupled with real meteorological analyses or forecasts. The wind-profilers network is composed of five ST radars located in strategic places, offering high-frequency recording of the vertical profiles of the three components of the winds, and of atmospheric reflectivity fields which can be used to estimate the tropopause height. The experimental system is used to investigate a real case of COL formation, issued from the ESTIME experiment (Bertin et al., 1997).

SIMULATION OF A STRATOSPHERIC INTRUSION EVENT AT SUBTROPICAL LATITUDES USING A COUPLED CHEMISTRY-GENERAL CIRCULATION MODEL.

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An important source of O3 in the troposphere is downward transport from the stratosphere through tropopause foldings associated with large scale cyclogenesis, cut-off lows and quasi-adiabatic transports along isentropic surfaces at mid-latitudes. Stratosphere-troposphere exchange (STE) processes co-determine the distribution of O3 in the troposphere, and knowledge of its influence on tropospheric O3 levels is necessary to assess the climate effects of O3 perturbations due to human activity. A tropopause folding event associated with the development of a cut-off low over southeastern Europe at the end of March 1995 enhanced the ozone concentrations in the upper troposphere. The episode has been simulated using a coupled chemistry-GCM that has been 'nudged' towards actual meteorology using a simple four-dimensional assimilation technique based on ECMWF data. The GCM used is the European Centre Hamburg Model, version 4 (ECHAM-4). Results of the model run are compared with observational and analysed meteorological data. In particular, simulated geopotential heights show a realistic representation of the synoptic development of the cut-off low system. The model also successfully reproduce the space-time evolution of potential vorticity and specific humidity fields associated with the tropopause fold. Furthermore, modelled O3 concentrations during that period show a pronounced increase in the upper troposphere associated with downward fluxes from the stratosphere. The good qualitative (and in many cases quantitative) agreement between the simulated and observed stratospheric intrusion event shows that the model provides a useful tool to analyse stratosphere-troposphere exchange processes and their effect on the tropospheric ozone budget.

ANALYSIS OF TRANSPORT AND EXCHANGE PROCESSES IN THE TROPOPAUSE REGION BY MEANS OF LAGRANGIAN METHODS

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This paper is focusing on Lagrangian studies of the dynamical processes in the tropopause region. A case study is presented analysing air mass transport within a trough and a streamer developing therefrom in February 1997. The episode was simulated using the EURAD model system designed for mesoscale meteorological and chemistry transport simulations. The air mass flow was analysed by two Lagrangian methods – contour advection and trajectory analysis – which are implemented as postprocessors of the meteorological model MM5 in the EURAD model system. The results of the contour advection studies are compared with measurements carried out during a Transport of Ozone and Stratosphere–Troposphere Exchange (TOASTE) campaign on February 4 and 5, 1997. The Airborne Lidar for Tropospheric Ozone (ALTO) flown on the French Fokker 27 measured thin ozone rich layers in the free troposphere the origins of which were determined by the use of contour advection. For quantitative estimates of stratosphere–troposphere exchange the analysed area was embedded in a three–dimensional box covering the upper troposphere and lower stratosphere. 21000 forward trajectories were released within the box and potential vorticity and temperature were calculated along the trajectory path. Thereby we can determine whether the air parcels have crossed the tropopause. The results of these flux estimates are compared with results of Eulerian calculations (budget calculatiòns and Wei's formula).

A CRITERION FOR THE FORMATION OF FILAMENTS AROUND THE POLAR VORTEX.

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The study of Lagrangian accelerations in geophysical turbulence allows to partition the fluid into regions with different dynamical properties (B.L. Hua and P. Klein, Physica D, 1997). The partition is based on the eigenvalues of a linear operator, describing the evolution of particle dispersion or of tracer gradients. The analysis is applied here to diagnose the formation of steep gradients and the generation of filaments around the polar vortex in the stratosphere during two study periods in January 1992 and February 1995. By comparing with contour advection calculations, it is shown that the eigenvalues can be used as a predictor of the formation of filaments on the boundary of the vortex.

TRANSPORT SIMULATIONS OF NATURAL TRACERS WITH THE ECHAM GCM: SENSITIVITY OF STRATOSPHERE–TROPOSPHERE EXCHANGE TO THE VERTICAL RESOLUTION

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The global distributions of SF_6 and ^{14}C from above–ground nuclear weapon tests have been simulated with two versions of the atmosphere general circulation model ECHAM: the standard version with 19 layers and a vertical resolution of approx. 2 km in the tropopause region and a modified version with the same model top, but 39 layers and about 1 km vertical resolution. Both trace substances are of anthropogenic origin and long–lived. SF_6 is emitted continously at the surface, whereas bomb produced ^{14}C has been introduced rather instantaneously in the northern hemispheric stratosphere. Because of their different source regions, this tracer pair represents a suitable combination for evaluating vertical transports in either directions. The models' transport characteristics are analysed with regard to stratosphere-troposphere exchange in terms of adjustment times. The simulation results are compared with observed concentration distributions.

THE RELATIONSHIP BETWEEN THE EXCHANGE ACROSS THE SUBTROPICAL BARRIER AND PLANETARY WAVE ACTIVITY IN A GLOBAL MODEL.

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The exchange of air from the tropics into midlatitudes across the stratospheric subtropical barrier is investigated in terms of potential vorticity fields on isentropic levels in a global 3-d mechanistic gridpoint model.
Vacillations of the planetary wave activity are caused by the two concurrent effects of a steady state forcing at the lower boundary at 200 hPa with observed geopotential height climatologies, which pull the model away from the zonal mean initial state, and by the Newtonian Cooling parametrization of diabatic heating, which relaxes the model temperatures to the zonal mean radiative equilibrium temperature.
In order to investigate the behaviour of the stratospheric subtropical barrier under different climatological situations, we have performed two 1000 day model simulations with an 'ENSO (EL Niño/Southern Oscillation) cold' and an 'ENSO warm' forcing at the lower boundary. The overall evolution of the model stratosphere is in accord with the observations of ENSO cold and ENSO warm years. Exchange events across the subtropical barrier always occur during periods with large wave activity.

Transport and mixing of a long-lived stratospheric intrusion in the upper troposphere.

Ground-based lidar measurements of ozone and aerosol profiles above Fritz Peak Observatory near Boulder, Colorado (40N,105W) are used in conjunction with radiosonde profiles and satellite water vapor imagery to characterize the structure of a dry, ozone-rich streamer of stratospheric air that appeared in the upper troposphere over the western United States on June 30, 1997. The streamer remained intact through more than six hours of observations before being rapidly dissipated through convective mixing induced by the incursion of a moist subtropical air mass between the streamer and the convective boundary layer. Potential vorticity analyses and isentropic back trajectories are used in conjunction with water vapor imagery to show that the streamer evolved from a stratospheric intrusion that took place approximimately 10 days earlier and more than 8,000 km from Colorado above East Central Asia.

SPATIAL AND TEMPORAL VARIABILITY OF TROPOPAUSE FOLDS OCCURENCE - IMPLICATION FOR THE CROSS TROPOSPHERIC OZONE FLUX

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A climatology of tropopause folds has been established by using two data sets of together more than 10000 vertical ozone, temperature, relative humidity and wind profiles. The profiles were obtained either by ozone/radiosoundings (made available by WODC) and by in-situ measurements on commercial aircraft (MOZAIC project). An automatic detection algorithm for tropopause folds was developped and validated by extensive meteorological analysis. We found that folds were more abondant over North America (10 % of the soundings) than over Japan (7%) and Europe (4%). Also within continents, strong spatial differences were encountered. Another interesting result was that the folding occurrence showed a significant positive trend over North America and over Europe, more folds being detected especially in the nineties. An attempt will be made to correlate these results with climatolgies of other meteorological parameters / tracers (e.g. cyclone occurrence, ...). The fold occurrence was combined with litterature estimates of the ozone amount transfered in single events, in order to derive the regional and northern hemispheric ozone flux across the tropopause.

TRANSPORT IN THE MIDDLE ATMOSPHERE (MA) ECHAM GENERAL CIRCULATION MODEL

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The simulation of the large scale transport in the MA/ECHAM general circulation model is evaluated by analyzing the multi-year and three dimensional evolution of two tracers: SF6, a tracer with specified sources at the surface, linearly increasing with time, and a C14 tracer cloud, initialized in the polar lower stratosphere. The MA/ECHAM model is the middle atmosphere version (surface to 0.01 hPa) of the ECHAM4 general circulation model. Among novel aspects, the MA/ECHAM model includes a parameterization of the effects of a continuous spectrum of gravity waves. The MA/ECHAM model will be used in simulations including active feedbacks with chemical models, one motivation for first evaluating its passive tracer transport. Given that the MA/ECHAM model include the middle atmosphere, it is possible to investigate the role of the large scale residual circulation encompassing the middle atmosphere on the stratosphere-troposphere exchange.
Availability of several observations of SF6 and C14 concentrations allows a comparison with the simulation results. The characteristics of the upward transport in the model are elucidated by the temporal evolution of the SF6 tracer. It is shown for instance that most of the upward transport is occurring in the tropics and therefore a meridional gradient in the SF6 tracer concentration develops along the 400 K isentrope. From the analysis of the C14 tracers it is possible instead to deduce the location and seasonality of the downward transport.

PSEUDO-CONTOUR ADVECTION WITH SURGERY.

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Contour advection is frequently used to reconstruct small-scale structures of potential vorticity or tracers on isentropic layers. The main assumption of this method is that the evolution of the field remains purely adiabatic over a finite integration time. We present a modified version of contour advection in which large-scale information, collected either from operational weather analysis or from satellite measurements, can be included. The modification introduces a large-scale pseudo-velocity which moves the contour in order to preserve the large-scale constrains provided by the observations, and generates new contours when required. The new algorithm can be used in an on-going assimilation procedure unlike standard contour advection which is applied as a series of initial value problems. The method will be demonstrated on a idealized case. We hope to present also results on the formation of the 0_3 collar around the southern hemisphere late winter polar vortex.

COMPARISON OF RDF WITH IN-SITU DATA

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Over the last few years there have been an increasing use of two trajectory techniques (Contour Advection and Reverse Domain Filling (RDF) Trajectories) to assist in the visualization of flows. Although the initial motivation for this work came from dynamical studies of simple model atmospheres. The technique has been applied with qualified success to a number of real atmospheric situations where more or less reliable large scale dynamical wind fields are available. The outcome of these studies have been mixed with some studies concluding that they are at best qualitative while other studies have shown apparantly remarkable agreement. In this talk the RDF technique will be used to 'reconstruct' a PV distribution at high resolution that contains structural feature of similar scale to insitu aircraft observations. Under some circumstances encouraging agreement is obtained between structures in the aircraft observations and features in the reconstructed PV. Reasons for the agreement and disagreement will be discussed.

OBSERVATIONS OF TRACE GASES IN THE VICINITY OF A TROPOPAUSE FOLD

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Tropopause folds are one of the final steps in the transport and modification of air from the tropics to northern latitudes through the stratosphere. Classical tropopause fold studies concentrate on the flux of dry ozone rich air from the stratosphere into the troposphere. In this study we will present composition measurements of ozone and condensable vapours such as water vapour. Evidence will be presented that indicates the nett transfer of water vapour into a tropopause fold giving the possibility that although in fold events the main transfer is from the stratosphere to the troposphere there may be a reverse flux of moisture (but not air) from the troposphere into the stratosphere. Further evidence for the existance of such processes will be discussed.

ST16

ON THE ADVECTION OF HIGH RESOLUTION TRACERS BY LOW RESOLUTION WINDS

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Recently Lagrangian techniques have been employed to study the global transport of atmospheric chemicals. Large scale strain tends to dominate the appearance and positioning of tracer filaments so that tracers simulated using coarse-grained wind fields to integrate the trajectory equation closely resemble those simulated using the highest resolution analyses available. Here, it is shown that although contour stretching rates are very insensitive to the spatial truncation of the wind field the displacement errors in filament position are sensitive. A quantitative lower estimate is obtained for the tracer scale factor (TSF): the ratio of the smallest resolved scale in the advecting wind field to the smallest width above which all filaments are accurately positioned by a contour advection (CA) simulation. For a baroclinic wave life cycle the TSF=6.1 ± 0.3 whilst for the NH wintertime lower stratosphere the TSF=5.5 ± 0.5. Uncertainty in contour initialisation is investigated for the stratospheric case. The effect of smoothing initial contours is to introduce a spin-up time, after which wind field truncation errors take over from initialisation errors (2-3 days). It is also shown that false detail from the proliferation of fine-scale filaments limits the useful life-time of such CA simulations to 7-10 days.

STUDY OF STRATOSPHERE TROPOSPHERE EXCHANGE AT HIGH LATITUDES WITH MST RADAR AND OZONESONDES

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The ESRAD MST radar, located at Esrange (68°N, 21°E), made continuous measurements of winds and layering structure in the troposphere and lower stratosphere during the entire winter 1996/97, and will continue to make measurements during the winter 97/98. One of the many atmospheric features which are detected by the radar is the tropopause and the layer of lowermost stratospheric air just above the tropopause, which give distinctive signatures in altitude profiles of radar echo power. On several occasions during the winter of 1996/97 the radar tropopause over Esrange was observed to branch. Using meteorological maps and ozone sondes we show that most such ESRAD features also correspond to frontal zones. Comparison with ozonesondes also shows that the weak and low tropopause in a trough can be identified with the MST radar. However, on a number of occasions a region of enhanced radar echoes extending from a trough corresponded to regions of stratospheric air (high ozone content / low humidity) as identified by ozonesondes. It therefore seems possible to monitor the stratospheric intrusion with the radar, if it can be identified as a stratospheric airmass with ozonesonde data. Results from such combined radar - ozonesonde measurements during the the winters 96/97 and 97/98 will be presented.

Chemical impact on the troposphere of tropopause fold events during TOASTE campaigns.

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Tropospheric ozone is an important greenhouse gas and atmospheric oxidant, playing a key role in the composition of the troposphere. There are two primary sources of tropospheric ozone: downward flux of ozone from the stratosphere into the troposphere, and the photo-oxidation of ozone precursors from anthropogenic and natural sources.
We have developed a tropospheric chemical transport model, TOMCAT, with meteorology forced by ECMWF analyses. The model contains a detailed description of tropospheric chemistry. Stratosphere-troposphere exchange (STE) events in March 1995 and June 1996 have been studied during the TOASTE-B and C (Transport of Ozone And Stratospheric Tropospheric Exchange) campaigns. We compare these observations with TOMCAT.
The importance of STE on the tropospheric distribution of chemical trace species is discussed.

MIXING BETWEEN STRATOSPHERE AND TROPOSPHERE STUDIED WITH NCAR/CCM3

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We have used the winds and thermal structure obtained from a simulation with NCAR/CCM3 General Circulation Model to advect parcels in an isentropic offline model. A number of calculation have been performed with parcels initialized on different θ surfaces, from 330 K to 400 K. This range of θ's spans the lower-most stratosphere. Using isentropic potential vorticity, we have been able to distinguish air of tropospheric nature from stratospheric air. Parcel calculations were performed in different seasons to study the variability of mixing. Calculations in which the parcels were initialized on θ surfaces intersecting a large part of the tropical troposphere have shown that, in the presence of synoptic disturbances at mid-latitudes, mixing is an efficient process that produces substantial lateral exchange of air masses. At higher latitudes, sinking is a more prominent feature. In order to provide a quantitative estimate of the mixing, we have calculated horizontal diffusion coefficients from the dispersion of air parcels about their "center of mass".

DYNAMICS AND TRANSPORT IN THE LOWER STRATOSPHERE

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This talk will comprose an overview of recent developments in our understanding of lower stratospheric dynamics and transport. The gross mass flux across isentropic surfaces is associated with the diabatic circulation, which in middle latitudes is now recognized as being driven by waves through the "extratropical pump" mechanism. However, the observation that upwelling is concentrated in the tropics is somewhat perplexing, given that, if wave breaking is confined to the midlatitude surf zones, and the stratosphere is linear and inviscid, upwelling would concentrate at the subtropical edge of the surf zone. Relevant results from a zonally symmetric model will be described.
Observations of lower stratospheric tracers will be interpreted, with the aid of a "leaky tropical pipe" model of the stratosphere, to put constraints on our understanding of transport across the key transport barriers—the subtropical edge, the tropical tropopause, and the midlatitude tropopause.

A CASE STUDY TO IDENTIFY LAYERS WITH LAMINAR OR TURBULENT FLOWS USING ST RADAR AND RADIOSONDE OBSERVATIONS AND TRAJECTORY CALCULATIONS

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Continuous tropo/stratospheric investigations of the polar atmosphere have been carried out with the ALOMAR SOUSY radar (53.5 MHz) in Andenes, Norway (69° N, 16° E) during the winters 1995/96/97. The radar measures wind and static stability (or power) profiles, and are used together with high-resolved radiosonde soundings to track the evolution of these parameters as air masses with low or high PV crosses the site. Trajectory calculations provide information on the origin of the layers derived from radar and radiosonde signatures.
In addition, the wind profiles obtained by radar and radiosonde can be used to identify gravity waves, and their potential contribution to lamina formation will be evaluated.

STRATOSPHERE-TROPOSPHERE EXCHANGE WITHIN A CUT-OFF LOW: AIRBORNE MEASUREMENT CAMPAIGN AND MESOSCALE MODELLING

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In June 1996, a Transport of Ozone and Stratosphere-Troposphere Exchange (TOASTE) campaign was set up to study the evolution of a cut-off low system after its removal from the general circulation. The Airborne Lidar for Tropospheric Ozone (ALTO) was flown on the French Fokker 27 research aircraft. Ground based measurements and radiosondes are also available. The use of an aircraft allows us to follow the system for several days and many two-dimensional ozone and aerosol backscattering coefficient vertical cross-sections through it are available. The observed decay of the cut-off low is investigated in association with the question of irreversible transport. The use of a meteorological mesoscale model (MM5) helps us tackling the question of diabatic erosion as a possible transfer mechanism. This turns out to take place mostly on the eastern flank of the cut-off low. Ozone filaments are also observed and the model ability to account for the measured ozone structures is also investigated. Specifically, the question of the best corresponding modelled quantity is raised. Potential vorticity is not the only useful one: more attention should be paid to the dry layers generated by the model.

INVESTIGATING TRANSPORT ACROSS THE TROPOPAUSE.

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Observations of chemical tracer show a sharp contrast across the tropopause. It therefore appears that the tropopause may act as a barrier separating two well mixed regions, analogous to the polar vortex edge in the lower stratosphere. Isentropic advection studies are used to investigate this barrier and to quantify its leakiness.
Particle and contour advection studies have often been used to quantify transport via stretching rates. However, the results of these diagnostics have been somewhat ambiguous in the case of the tropopause. It is argued that problems arise because the tropopause is a highly asymmetric and leaky barrier. An alternative diagnostic has been used to overcome these difficulties by calculating an effective diffusivity as a function of an equivalent latitude coordinate defined in terms of the area within tracer contours, following Nakamura (1996: J. Atmos. Sci., 53, 1524). Observed velocities from isentropic surfaces intersecting the tropopause are used to advect tracer and the effective diffusivity is calculated as a diagnostic from the tracer field. A clear minimum in effective diffusivity is seen and it is proposed this should be identified as the tropopause. The relation between this and more conventional definitions of the tropopause, e.g. defined in terms of particular values of potential vorticity, is discussed.

THE RESIDUAL MEAN MERIDIONAL CIRCULATION IN THE LOWER STRATOSPHERE, DIAGNOSED FROM 15 YEARS OF ECMWF-REANALYSIS DATA

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In the lower stratosphere the mean trajectories of air parcels form one meridional cell in each hemisphere, with upward motion in the tropics, poleward flow at middle latitudes and downward motion into the troposphere at higher latitudes. This Lagrangian-mean circulation can be approximated by the transformed Eulerian mean (TEM) circulation, which is the Eulerian mean circulation in which the part forced by eddy heat transport is removed.

The TEM circulation can be obtained from meteorological analyses as produced by numerical weather prediction (NMP) models. The required circulation data, particularly the vertical velocity, are, however, sensitive to the formulation of the model. Therefore, the TEM circulation diagnosed for a period of several years might show spurious jumps due to changes in the model during that period. This problem, however, can be overcome by using reanalysed data that for the whole period are produced by one (state-of-the-art) version of the NMP-model.

In this study the TEM circulation in the lower stratosphere is diagnosed from 15 years (1979-1993) of ECMWF-reanalysis data. Results will be presented for the height and latitudinal dependence of the circulation, as well as for its seasonal and interannual variability.

STRATOSPHERE-TROPOSPHERE EXCHANGE IN A STRATOSPHERIC INTRUSION

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The so-called "advection method" for calculating stratosphere-troposphere exchange (STE) has been refined in order to be able to calculate mass exchange also in the case of a multi-folded tropopause. STE was calculated from a numerical simulation of the heavy precipitation event which occurred from 5 to 7 November 1994 in the southern Alps. It was instigated by a pronounced stratospheric intrusion. The investigation aimed at isolating the contribution of each diabatic and turbulent process on the mass exchange at the tropopause. For this, the tendencies of momentum and temperature due to the various physical processes were stored together with normal output during the model run. The full 3-dimensional potential vorticity tendency equation could then be solved and the mass exchange at the PV-defined tropopause calculated. Results show the dominant role of horizontal diffusion of momentum and temperature for STE which is much larger than the contribution of vertical mixing. Other processes like moisture physics and radiation vary strongly through the life cycle of the stratospheric intrusion. The results highlight the strong dependence of STE on the representation of physical processes in a mesoscale model.

OBSERVATIONS OF THE TROPOPAUSE REGION ABOVE ANDENES DURING THE BREAK UP OF THE POLAR VORTEX IN MARCH 1995 WITH THE ALOMAR SOUSY RADAR

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The ALOMAR SOUSY radar, operating on 53.5 MHz at Andenes (69.3°N, 16.0°E), has performed continuous tropo/stratospheric observations from January through March 1995 using the Doppler beam swinging (DBS) technique. The radar measures wind and reflectivity profiles with 300 m range resolution and 5 min time resolution, in addition, a radar tropopause height and vertical momentum fluxes are derived. The variability of the tropopause region was investigated in detail during the break up of the polar vortex in March 1995. During the passage of an anticyclone south of Andenes the radar observes strongly enhanced zonal and meridional wind velocities at tropopause heights between 10 and 11 km. The passage of the jet is connected with enhanced wave activity above the tropopause as indicated by vertical momentum fluxes. On the following days a decrease of the tropopause height by about 3 km was detected and wave activity was not present. The estimated radar tropopause height is in good agreement with balloon soundings.

STRATOSPHERIC–TROPOSPHERIC–EXCHANGE: A PINATUBO CASE STUDY

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Stratospheric–tropospheric exchange (STE) processes are one of the major problems of the 3d transport simulations with general circulation models. The simulation of the STE in the tropical lower stratosphere is especially crucial. The volcanic eruption of Mt. Pinatubo, in June 1991, had not only significant impact on stratospheric and tropospheric climate and circulation, it is also a natural phenomenon which enables us to better understand STE processes, especially in the tropical region. For the Pinatubo period (1991 -1993) a large amount of observations exist, which offer a unique opportunity to verify and to test the representation of the STE and the 3d transport in a global model. In using different versions of the Hamburg climate model ECHAM4: ECHAM4_L19, ECHAM4_L39(DLR), MA/ECHAM4 (L39,L69), we performed a set of Pinatubo simulations with prognostic aerosol. Here we present results of these different numerical experiments for the years 1991 and 1992 and comparisons with satellite data and in situ measurements at different stations. It will be shown that both a fine model resolution in the tropopause region and a high top of the model atmosphere are necessary to adequately represent the observed transport characteristics of a major volcanic eruption. The importance of an interactive treatment of the volcanic cloud will also be evidenced.

OZONE-RICH TRANSIENTS IN THE UPPER EQUATORIAL ATLANTIC TROPOSPHERE

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High concentrations of ozone are found in the Earth's stratosphere, but strong stratification suppresses efficient exchange of this ozone-rich air with the underlying troposphere. Upward transport of tropospheric trace constituents occurs mainly through equatorial deep convective systems. In contrast, significant downward transport of ozone-rich stratospheric air is thought to take place only outside the tropics by exchange processes in upper-level fronts. Ozone within the tropical troposphere is assumed to originate predominantly from ground-based emissions of ozone precursors rather than from a stratospheric source. Recent measurements of ozone in the upper troposphere in convective regions over the Pacific Ocean indeed reveal near-zero concentrations. Here we present sharply contrasting observations: ozone-rich (100–500 parts per billion by volume) transients were frequently encountered by specially equipped commercial Airbus 340 aircraft (MOZAIC project) at a cruising altitude of 10–12km in the vicinity of strong convective activity over the equatorial Atlantic Ocean. This strongly suggests that the input of stratospheric ozone into the troposphere can take place in the tropics. We suggest that this transport occurs either by direct downward movement of air masses or by quasi-isentropic transport from the extratropical stratosphere.

SEASONAL VARIATION OF STIRRING AND MIXING IN THE LOWER STRATOSPHERE

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Mixing processes in the lower stratosphere are examined using trajectory calculations, in-situ trace gas observations, and a simple strain-diffusion model. The quasi-horizontal stirring and generation of filamentary structures by the large-scale flow is examined by performing trajectory calculations driven by analysed winds. These calculations are used to calculate the rate of reduction in scale, and orientation, of filamentary structures. High-resolution trace gas measurements from the series of NASA ER-2 aircraft campaigns (which span the different seasons) enable the fine-scale structure of filaments to be examined. Also, tracer-tracer scatter plots can be used to identify partially mixed filaments. The trajectory calculations and aircraft observations are used together with a 1-D strain diffusion model to quantify the mixing of filaments: in particular, the effective diffusivities and "mix-down" time of the filaments are estimated. Calculations during winter/spring indicate that the time scale for horizontal scales of 1000 km to be reduced to mixing scales is around 10 to 15 days, and that complete mixing occurs within a month. However, preliminary analysis of summer conditions suggest that there is much weaker stirring and mixing, and that the mix-down time of filaments is longer than 2 months.

EVALUATION OF THE SEASONAL CYCLE OF WATER VAPOR IN THE STRATOSPHERE DERIVED FROM MONTHLY AVERAGE TROPICAL TROPOPAUSE TEMPERATURES USING A CO PHOTOCHEMICAL CLOCK

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In situ measurements taken on the NASA ER-2 aircraft during the STRAT campaign during 1995 and 1996 included a series of dives in the tropical lower stratosphere. With a simple photochemical model, observed CO profiles provide a measure of the photochemical age of the air in the stratosphere. Using this age as the transit time of the airmass from the tropical tropopause to its measured altitude, we compare measured CO2 and water vapor mixing ratios with entry-level mixing ratios corresponding to the date the air mass crossed the tropical tropopause. These comparisons demonstrate that water vapor saturation mixing ratios derived from monthly-averaged radiosonde temperatures at the tropopause between 10S and 10N represent the boundary condition for water vapor reasonably well. We also demonstrate that most of the disagreement between boundary condition mixing ratios and measured values is a result of the mixing of midlatitude air. Ascent velocities in the tropical lower stratosphere determined from plots of photochemical age vs. potential temperature will also be presented.

DIAGNOSING EXTRATROPICAL STRATOSPHERE-TROPOSPHERE EXCHANGE: A CASE STUDY

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The chemistry and the distribution of trace gases in the lowermost stratosphere cannot be understood without a quantitative knowledge of the synoptic (and smaller) scale transport between stratosphere and troposphere. In this paper several different methods to diagnose the synoptic-scale stratosphere-troposphere exchange are applied and compared to each other in the framework of a case study. A case with strong convective heating in a decaying cut-off cyclone is selected. A consistent data set is obtained through a special ECMWF-model run with standard resolution, but enhanced output storage. Despite the strength of the cross-tropopause mass exchange during the episode the different diagnostic methods yield quite different results. In particular some of the more popular methods based on Wei's (1987) formula have to be treated with care. Intercomparison of the different methods helps to understand some of the problems.

CASE STUDY OF STRATOSPHERE TROPOSPHERE EXCHANGE USING VHF WIND PROFILER, OZONESONDE, RADIOSONDE AND E.C.M.W.F. DATA.

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Recent results, including some from European campaigns CWINDE (COST Wind Initiative for Network Demonstration in Europe) and FASTEX (Fronts and Atlantic Storm Tracks Experiment), are used to examine a stratosphere-troposphere exchange event on 8-9 March 1997, where ozonesonde and radiosonde data indicate an intrusion of dry, stable, ozone-rich air as low as 3 km altitude above Aberystwyth. Data from the VHF radar at Aberystwyth are employed, with the dependence of radar echo power on humidity investigated statistically using output from January-March 1997. VHF echo power is found to be reduced for both dry and saturated air; nevertheless, layers in the echo power structure associated with dry stable air can be tracked. ECMWF analyses of trajectories and potential vorticity fields will also be presented.

AIRBORNE CO_2, CH_4, O_3, AND SF_6 MEASUREMENTS TO STUDY TRACER TRANSPORT AROUND THE TROPOPAUSE

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Whole air samples to measure the mixing ratios of carbon dioxide, methane, ozone, and sulfur hexafluoride were collected around the mid- and high-latitude northern tropopause in the winter months (December to April) 1993/94 and 1994/95. The samples originate to the same part from the upper troposphere, mainly from the 400 hPa pressure level, and from the lowermost stratosphere up to altitudes of 12 km. By evaluating potential temperatures of the examined air parcels and derived trace gas - trace gas correlations, three types of tropospheric air masses could be distinguished: mid-latitude, polar, and arctic air. As confirmed by isentropic back trajectory calculations, the mid-latitude upper troposphere was frequently suffered by polluted air from the low troposphere resulting in a positive correlation of CH_4, SF_6, and O_3. In contrast, in the high-latitude upper troposphere as well as in the lowermost stratosphere, first, the encountered air masses were better mixed, and second, both CH_4 and SF_6 were negatively correlated with O_3. Furthermore, caused by the actual strong SF_6 growth rate of nearly 7% per year, the age of the observed air masses since their entry into the stratosphere could be inferred. This SF_6-age was surprisingly high, e.g. around two years in an altitude of 11.5 km and thus just 3 km above the local dynamical tropopause.

A SUMMER STRATOSPHERIC INTRUSION EVENT AT JUNGFRAUJOCH (3,580 M ASL) IN SWITZERLAND

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Very high ^{7}Be activity concentrations (>11 mBq/m^3 at STP) were recorded at Jungfraujoch in the Swiss Alps from 16 to 23 July 1996. In addition, half-hourly ozone concentrations exceeded 80 ppbv on 19 and 20 July 1996. The synoptic pattern at the 500 hPa level revealed an eastward-moving upper trough-ridge system over North Atlantic and Scandinavia. Vertical SW-NE cross-sections of isentropes indicated a low tropopause over Scandinavia on 17 July. Time-height plots of temperature, potential temperature, y-axis (north-south) kinetic energy, specific humidity and ozone from the aerological soundings at Payerne all suggested that the high ^{7}Be and ozone levels were associated with a stratospheric intrusion event above the northern Atlantic-Scandinavia region, followed by anticyclonic subsidence and strong advection to the Jungfraujoch. Ensembles of kinematic 3-D back-trajectories calculated from ECMWF analyses, arriving at Jungfraujoch on 19 and 20 July, were found to be consistent with the observations. Although, the original stratospheric intrusion occurred more than one thousand kilometres away from Jungfraujoch, it was, nevertheless, able to enhance both ^{7}Be and ozone concentrations at the site. The study was carried out within the EU project "VOTALP" (Vertical Ozone Transport in the Alps).

ST17 Aviation and space flight (co-sponsored by OA)

01 Aviation impact on the atmosphere

Convener: Kelder, H.
Co-Convener: Sausen, R.

EFFECTS OF ATMOSPHERIC TEMPERATURE FLUCTUATIONS WITH ESTIMATION OF SUPERSONIC AVIATION IMPACT ON OZONE LAYER OF THE EARTH

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A two-dimensional zonal-average model of diabatic circulation and gaseous and aerosol composition of the troposphere and stratosphere is used to examine a role the atmospheric temperature fluctuations play for estimates of 1990-2015 changes occurring in the ozone layer as a result of NO_x, SO_2, CO_2, CO, and CH_4 emissions from supersonic aircraft. The model uses the zonal mean temperature ($\bar{T}$) variations derived from a temperature probability distribution. This distribution was obtained from the US National Meteorological Center's temperature data. We show that the atmospheric temperature fluctuations are very important for the estimates of supersonic aviation effects on ozone in both middle and high latitudes of the Northern Hemisphere. For example, a scenario for chlorine background $3ppbv$ with 100% gaseous SO_2 and NO_x injections from supersonic ($2.4Mach$) aircraft with emission indexes of $0.4g$ and $15g$ per $1kg$ fuel, respectively, results in the relative total ozone change of -0.47% at $45°N$ and -0.71% at $70°N$ in March, without account taken for $\tilde{T}$ variations, and 0.75% at $45°N$ and -1.32% at $70°N$, with $\tilde{T}$ variations taken into account. The same scenario with SO_2 injection as 100% aerosol sulfate particles of $0.01\mu m$ radius results in the relative total ozone change of -1.05% at $45°N$ and -1.32% at $70°N$, without account taken for $\tilde{T}$ variations, and -1.35% at $45°N$ and -2.50% at $70°N$, with $\tilde{T}$ variations taken into account.

IS THERE ANY OBSERVABLE INCREASE IN CIRRUS CLOUD DUE TO AVIATION DURING 1982–1991?

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Emissions of exhaust aerosol and water vapour by aircrafts are responsible for the formation of condensation trails (or contrails). Exhaust aerosols may also indirectly alter cloudiness by increasing the occurrence of 'natural' cirrus. We analyze synoptic cloud reports from ships and land stations for the period 1982–1991, a decade of large increase in the total fuel consumption by aviation. The changes in cirrus cloud occurrence and cirrus cloud amount are estimated from the surface observations and a relation is sought with the geographical distribution of aviation fuel consumption.

THREE-DIMENSIONAL MODELING STUDIES OF THE IMPACT OF AIRCRAFT EMISSIONS ON ATMOSPHERIC OZONE: SENSITIVITY TO EMISSION INDICES, H_2O, AND SULFUR CONVERSION

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The NASA Langley three-dimensional chemistry transport model (CTM) is used to examine the impact of future subsonic and supersonic aircraft emissions on ozone. The model includes a full representation of stratospheric chemistry as well as parameterizations treating the reactions occurring on polar stratospheric clouds and on sulfate particles. Multiple simulations using scenarios from the recent Intergovernmental Panel on Climate Change (IPCC) model intercomparison have been conducted with the Langley CTM to characterize the response of ozone to varying aircraft NO_x emission indices, the efficiency of sulfur conversion to sulfate particles in the exhaust, and the emission of H_2O. The inclusion of H_2O engine emissions significantly increased the calculated aircraft impact on ozone compared to a calculation with only NO_x emitted, particularly at low NO_x emission indices. Engine sulfur conversion to sulfate particles also led to larger ozone decreases. Recent assessments of the effects of stratospheric aircraft on the atmosphere have emphasized the need to quantify the uncertainties in model predictions. We will compare and contrast our calculations to other 2- and 3-D model studies and examine the principle sources of uncertainties.

The IPCC Special Report on Aviation and the Global Atmosphere: the impact of future subsonic aircraft emissions.

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Using a host of 3 dimensional global tropospheric models the impact of future sub-sonic aircraft emissions on the concentrations of O3, OH and NOx was estimated for the years 1992, 2015 and 2050. These model calculations will be used for the forthcoming IPCC Special Report on Aviation and the Global Atmosphere. The models differ in their formulation of vertical and horizontal resolution, transport, boundary conditions and chemistry. Therefore, inter-model differences are large. We will discuss model results and the most important uncertainties.

THE IMPACT OF NO_X AIRCRAFT EMISSIONS ON ATMOSPHERIC COMPOSITION AND CLIMATE

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Changes in NO_x and ozone concentrations due to aircraft emissions, modelled with the dynamic-chemical general circulation model ECHAM3/CHEM, for the years 1992, 2015 and 2050 are presented. An estimate for the impact on climate will be given.
One of the most important sources of NO_x in the upper troposphere are the emissions by aircraft. Since the ozone production in that area is largely controlled by NO_x, aircraft emissions have the potential to change significantly the distribution of the greenhouse gas ozone and temperature.
The paper especially concentrates on spatial and interannual variations of the NO_x background and aircraft NO_x pertubations as well as their possible changes in the future due to climate change.

NON-INTRUSIVE INFLIGHT INVESTIGATION OF AIRBUS A340 ENGINE EMISSIONS

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Passive mode Fourier transform spectrometry is used to perform non-intrusive measurements of jet engine emission indices. For the first time investigations of this kind were made on board of a commercial wide body aircraft. In cooperation with Airbus Industrie the customized and flight approved MIROR spectrometer was installed in the cabin of an Airbus A340. Test flights at various flight and engine conditions were performed from Toulouse/F focusing on the emission indices of the plume species NOx and CO, and the gas temperature close to the nozzle exit.

Results of this campaign and the comparison with emission data calculated from ground-to-altitude models will be presented.

MODEL STUDY OF ATMOSPHERIC POLLUTION BY AVIATION ENGINES IN THE NORTHERN TEMPERATE BELT

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The spatial and temporal courses of NO_X and HNO_Y content field formation over the northern temperate belt due to the transport aircraft flights intensity there in summer and winter and their diurnal schedule are evaluated as deviations from the zonal homogenity used in the 2-D photochemical models of the zonally and diurnally averaged atmosphere for the aircraft exhaust atmospheric effects. The transient 2-D photochemical model of tropospheric photochemistry and climatic air transport in the temperate belt (30° to 60°N) is used. The photochemical block includes about 170 gasphase and heterogeneous reactions among oxygen, hydrogen, nitrogen, carbon, chlorine and bromine species. Relevant up to 30-70% reductions in the NO_X emission are calculated for the 2-D model sources of zonally averaged exhaust product. The NO_X oxidation rates into HNO_3 and HNO_4 are rather high and sensitive to the ambient air temperature, but much lower during the nighttime.The influence of both the emitted NO_X and CO as exhausts products on the ozone, hydroxyl radical and other species behavior and on the redistribution of nitrogen compounds are discussed.

IMPACT OF SUBSONIC AIRCRAFT ON ATMOSPHERIC CHEMISTRY: MESOSCALE SIMULATIONS ON THE ROLE OF HETEROGENEOUS REACTIONS ON/IN SULFATE AEROSOLS

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The global amount of emissions from subsonic aircraft is to a high fraction released in the tropopause region. Many model studies suggest that in this altitude range aircraft induced NOx changes result in a significant increase of ozone. However, the influence of heterogeneous chemistry on the impact of subsonic airtraffic is currently not well understood. Sulfuric acid aerosols (SAA) contribute to a large extent to the aerosol burden of the lower stratosphere and the upper troposphere. In the present study Box- and 3D-mesoscale simulations are performed to elucidate the role of heterogeneous reactions on and in SAA in the chemical perturbations of the tropopause region caused by subsonic aircraft. For these calculations the EURAD-TS model system is applied which has been modified to enable the simulation of atmospheric distributions of SAA as well as heterogeneous conversions of several nitrogen-, chlorine- and bromine compounds on/in SAA. The considered heterogeneous chemistry generally reduces the chemical life time of the NOx exhaust. Despite this, in most simulated cases the aircraft induced ozone increase is enhanced strongly which is a consequence of important modifications of the NOx, HOx, ClOx and BrOx budgets caused by heterogeneous reactions. The simulated aerosol effects show considerable variations with altitude, season and aerosol loading.

Remote measurements of aircraft exhaust gas using FTIR spectrometry at industrial test-rigs

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Remote measurements of aircraft exhaust gas using FTIR spectrometry were performed in-flight under cruise conditions several times up to now (e.g. Haschberger and Lindermeir, JGR 101, 25,995-26,006, 1996 and Haschberger and Lindermeir, JRL 24, 1083-1086, 1997). For comparison and validation purposes FTIR measurements at an industrial test-rig were performed at ground conditions within the EU project AEROJET. These experiments were carried out with the same spectrometer that was used for the flight campaigns. The poster will present results which were obtained by applying different experimental setups for the detection of H2O, CO2, CO, NO, and NO2.

ANALYSIS OF 24 YEARS OF BALLON-BORNE AEROSOL DATA TO DETERMINE THE EFFECTS OF SUBSONIC AIRCRAFT

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The University of Wyoming balloonborne aerosol record, which spans approximately 26 years (1971-1997), was analyzed to determine possible effects of commercial aircraft on the 8.6 - 12.7 km (29 - 41 kft) altitude range of the atmosphere. An effort to identify condensation nuclei (CN) layers relative to seasonal background conditions in the commercial airlanes was undertaken. Generally, aircraft flight information is not available for past balloon soundings thus making it impossible to ascribe a source to observed CN layers. Under conditions coordinated with the U. S. Federal Aviation Administration, a CN layer observed in March 1997 was traced to a particular aircraft, thus supporting the hypothesis that at least some of the observed layers are contrail remnants. Using the Laramie data set, an attempt was made to quantify the enhancement of aircraft-induced CN layers in comparison with natural background levels. We estimate conservatively that the contribution of the commercial aircraft fleet in the vicinity of Laramie, Wyoming amounts to about 5-13% of the natural background, depending on season.

THE IMPACT OF AIR TRAFFIC IN THE NAFC: MODEL RESULTS VERSUS MEASUREMENTS

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The impact of aircraft emissions on the atmospheric composition has been investigated with a global chemistry transport model. The model calculations show that aircraft emissions contribute to about 40-80% of the background values of nitrogen oxides in the North Atlantic flight corridor and lead to an increase of the background ozone concentrations about 3-4% in winter and 5-7% in summer. The three-dimensional distributions of ozone, nitrogen oxides and nitric acid, calculated by using analyzed meteorological data, have been compared with airborne measurements performed in the North Atlantic flight corridor as part of the EC POLINAT project. The agreement between modelled results and observations is reasonably good. The perturbation of nitrogen oxides caused by aviation is expected to be observable due to its large magnitude, but the resulting ozone perturbation will in general be to small too distinguish it from the natural variability.

UPPER TROPOSPHERIC HO_x: SOURCES AND ROLE IN THE AIRCRAFT IMPACT ISSUE

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The injection of nitrogen oxides (NO_x) by aircraft is believed to enhance ozone production in the upper troposphere. However, ozone production depends on the availability of odd hydrogen radicals, HO_x. While the main production of HO_x in most of the troposphere is the O^1D+H_2O reaction, where O^1D is supplied by ozone photolysis, recent work showed that other sources are important in the very dry upper troposphere. Proposed sources are the photolysis of acetone and convectively injected peroxides. We use a global model to determine the relative importance of the different HO_x sources in the upper troposphere. The model suggests that 1/ ozone photolysis is the largest source at high latitudes, 2/ acetone generally plays a limited role, 3/ convection of peroxides (mostly CH_3OOH) and aldehydes are the dominant sources in the Tropics. The uncertainties, as well as the implications for the aircraft impact issue are discussed.

EMERGING NEW ATMOSPHERIC CHEMISTRY OF NITRIC OXIDE AND ITS IMPLICATIONS FOR THE AVIATION IMPACT ON THE ATMOSPHERE

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Assessment of the impact of aviation on the atmosphere (e.g., POLINAT & SONEX campaigns) is critically dependent on the accuracy of our knowledge about the sources and sinks of NO in the upper troposphere. This paper will therefore discuss a new source of NO which is predicted by shock tube data on the loss of NO and has now been experimentally confirmed (Zipf & Prasad, a paper in press in SCIENCE). This stratospheric source, which involves N_2 and O_2 directly (i.e., without the intermediary of N_2O) would considerably increase the flux of NO from the stratosphere into the upper troposphere. The new source also implies possible existence of an unrecognized sink of NO_y, since the current models already overestimate the NO_y even without the new source. Both implications could be important for POLINAT/SONEX. In addition, we will also discuss two other potential sources of NO_x involving the photodissociations of the N_2OO_2 (from the $N_2O + O_2$ (b) + M) and $N_2O \bullet O_3$ complexes. These sources are attractive since their strengths maximize in the 5 to 10 km region at values ≈1000 and 120 NO_x cm^{-3} s^{-1} respectively. It is hoped that the discussion will motivate the needed experiments.

ST17

CHEMICAL CONVERSION OF AIRCRAFT EMISSIONS IN THE DISPERSING PLUME: CALCULATION OF EFFECTIVE EMISSION INDICES

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A box model representative for a mesoscale volume and three different plume models are used to estimate the chemical conversion of exhaust species of a subsonic aircraft at cruise altitude. Clearly deviating results have been obtained for instantaneous mixing of the exhaust in a large scale box and gradual dispersion of a plume. The effect of varying daytime of release as well as the impact of changing dispersion time is studied with emphasis on the aircraft induced O_3 production. Effective emission indices are calculated for O_3, NO, HNO_3 and HNO_4. These effective emissions enable a correction for expanding plume effects in global or mesoscale models. The dependence of necessary corrections is investigated for different grid sizes.

3D STRATOSPHERIC MODELLING OF THE FUTURE EFFECTS OF AIRCRAFT EMISSIONS

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The upper troposphere and lower stratosphere are regions of great importance for ozone chemistry and climate change. Future emissions of nitrogen oxides from supersonic aircraft are predicted to further decrease ozone levels in an already depleted ozone layer.
We have used a 3D stratospheric model, SLIMCAT, to investigate the effect of future aircraft emissions in the years 2015 and 2050. The model was run for 18 months and the results form part of the model intercomparison for both the IPCC report on aircraft emissions and the EU AEROCHEM project. The SLIMCAT model is an isentropic off-line Eulerian transport model, where 'vertical' velocities are calculated using the Middle Atmosphere Radiation scheme (Shine, 1987) from the UGAMP Stratosphere Mesosphere Model.
The results of the SLIMCAT model are presented and the effect of future aircraft emissions on the distribution of chemical species during northern hemisphere winters is discussed. Model output using interactive ozone values to calculate diabatic heating are also compared to results using a climatological ozone field.

PARAMETRIZATION OF CONTRAILS IN A CLIMATE MODEL

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Sensitivity experiments with a comprehensive 3D climate model have shown that persistent contrails bear the potential of a significant climate impact. However, quantitative estimations of this impact require the use of a parametrization scheme, where contrails at some model grid box should depend on the instantaneous atmospheric state. Such a scheme has not been available for previous simulations.
We have developed two ways of parameterizing the coverage due to persistent contrails, both of which rely on the assumption that supersaturation with respect to ice may occur in part of some model grid box although the mean humidity value is below the saturation point. The first parametrization idea has been derived from (and is similar to) the cloud scheme of the climate model (ECHAM), the second one uses humidity measurements to derive characteristic values for humidity fluctuations within grid boxes of a size typical for the model's spatial resolution. The parameterized contrails obtain individual optical properties, which are calculated independently from those of natural cirrus in the same grid box. Optical depth and effective particle size associated with the simulated contrails are checked with results of a microphysical boxmodel.

THE INFLUENCE OF AIRCRAFT EMISSIONS ON THE GEOGRAPHICAL DISTRIBUTIONS OF OZONE AND RESERVOIR SPECIES IN THE UPPER TROPOSPHERE AND STRATOSPHERE

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The UIUC 3-D Atmospheric Chemical Transport model is used to estimate the influence of subsonic aircraft emissions on the geographical distribution of ozone and other species in the upper troposphere and stratosphere. Several 5-year-long steady-state model runs have been carried out for the boundary conditions of 1995 and the wind field derived from the UIUC 24-layer atmospheric general circulation model. A NASA dataset is used to describe the NOx emissions from the present-day subsonic aircraft fleet. The results of the simulations are compared with satellite and airborne measurements to estimate the ability of the model to simulate the ozone and NOy distributions in the upper troposphere and stratosphere. The comparison of model runs with a control run without the aircraft NOx source is performed to estimate the geographical and seasonal distribution of the changes in ozone and reservoir species caused by the aircraft emission. The model results show that the largest influence of aircraft NOx emissions occurs in the vicinity of the Atlantic flight corridor and in the area where heterogeneous reactions on Polar Stratospheric Cloud particles take place. The latter can be explained by the high sensitivity of the polar stratosphere to the changes in the intensity of HNO_3 sources.

A DIAGNOSTIC STUDY OF THE PRESENT AND FUTURE COVERAGE BY CONTRAILS

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The global distribution of the contrail formation potential and the contrail cloud coverage are estimated using ECMWF re–analyses data for temperature and humidity, and several data bases of aircraft fuel consumption (present day and future projections). By means of thermodynamic considerations the probability for the occurrence of persistent contrails is determined. This probability exhibits a rather strong geographical variability, with maxima in the tropics. The mean contrail cloud coverage is computed by multiplying this probability with a suitable function of fuel consumption (linear or non–linear). The product is normalized such that the contrail coverage equals the observed value of 0.5% in a domain between 30°W to 30°E, 35°N to 75°N. The impact of various aircraft emissions scenarios (present day, 2015, 2050) is analysed. Sensitivity studies are made with respect to the impact of propulsion efficiency and flight altitude.

IN-FLIGHT MEASUREMENTS OF AIRCRAFT NON-METHANE HYDROCARBON EMISSION INDICES

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Concentrations of non-methane hydrocarbons (NMHC), CO and CO_2 were measured in exhaust plumes of the DLR experimental aircraft ATTAS equipped with Rolls Royce M 45H Mk501 engines. The emission indices (EI) of individual light NMHC were determined from ratios of NMHC and CO concentration enhancements measured in grab samples and the concurrent in-flight measurements of EI of CO by FTIR emission spectroscopy and/or simultaneous fast continuous measurements of CO and CO_2. Alkenes and alkynes generated by cracking of larger NMHC molecules and aromatic compounds originating from unburnt fuel constituted a larger and a smaller fraction of the NMHC emissions, respectively. The EI(NMHC) were strongly dependent on the engine power setting.

THE POLINAT-2 EXPERIMENT: A STUDY OF LARGE-SCALE AIR TRAFFIC EFFECTS

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The POLINAT-2 (Pollution from Aircraft Emissions in the North Atlantic Flight Corridor) aircraft field campaign was performed in Sep./Oct. 1997 based from Shannon, Ireland. The objectives of the POLINAT-2 experiment were to investigate large-scale impact of subsonic air traffic in the North Atlantic flight corridor (NAFC), to evaluate the NOx budget in the upper troposphere, and to intercompare chemical aircraft measurements. Using the DLR Falcon a total of 10 missions were flown including north- and southbound survey flights in and around the NAFC. Also measurements during in-service flights of an instrumented Swissair B747 over the North Atlantic were performed. The flight planning was based on meteorological and chemical forecasts of University of Bergen and KNMI, respectively. A key partner in the investigation is the SONEX (SASS Ozone and Nitrogen Oxides Experiment) project which was deploying a NASA DC-8. Coordinated missions with SONEX include formation flights for instrument intercomparison and joint corridor track crossings. A preliminary data analysis indicates that large-scale corridor effects for air traffic NOx were observed.

AIRCRAFT NO_X IMPACTS ON TROPOSPHERIC OZONE

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The UK Meteorological Office off-line chemistry-transport model (STOCHEM) has been used to investigate the impact of subsonic aircraft NO_x emissions on tropospheric oxidants. NASA Aircraft emissions estimates for 1992, 2015, and 2050 have been used, whilst surface emissions follow the IPCC is92a scenario. Despite the non-linear chemistry of ozone, the increase in ozone scales nearly linearly with NO_x emissions, suggesting that ozone production in the upper troposphere is strongly NO_x-limited. A strong seasonal cycle is seen in the ozone perturbation due to aircraft NO_x, with a peak in spring. The reasons for this peak are thought to be due to the seasonal cycle in upper tropospheric NO_x, which reaches a peak in the Northern Hemisphere in summer, due to emissions from lightning. In addition, the chemical lifetime of ozone is much shorter in summer, due to the higher radical abundance. More vigorous convection during summer also readily mixes upper tropospheric ozone down towards the surface, where its chemical lifetime is shorter. The impact of PAN chemistry on the ozone perturbation is also investigated, by excluding PAN as a species in simulations with and without aircraft emissions. PAN plays a major role in the determination of background upper tropospheric NO_x.

IN SITU OBSERVATIONS OF AEROSOL PARTICLES IN JET AIRCRAFT PLUMES

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During the Sulphur 5 experiment in April 1997 fine mode aerosol particle emissions and contrail ice crystal distributions in the near field of the DLR research aircraft ATTAS have been investigated with respect to changing environmental conditions (dry exhaust and contrail), changing fuel sulphur content (20 ppm versus 3000 ppm) and volatile/ non-volatile aerosol fractions. Soot emissions were confirmed being independent from fuel sulphur content, amounting to 1.7E15 [#/kg]. Volatile ultra-fine aerosols larger than 5nm in diameter have been observed up to 2E17 [#/kg] for high sulfur and about 2E16[#/kg] for low sulfur fuel in the dry exhaust. Corresponding numbers in the presence of contrail ice crystals were clearly lower, namely 6E16 and 6E15, respectively. Significantly increasing trends with plume age were found for ultra-fine particles (>5nm) in the low sulfur and for Aitken nuclei (>14nm) in the high sulfur case, but exclusively in dry exhaust plumes. In contrast, a decreasing trend is evident for ultra-fine aerosols in contrail environment, which is consistent with scavenging time scales on contrail ice surfaces. A quantitative model analysis of the observed trends with respect to particle growth mechanisms will be subject of a further study.

GLOBAL IMPACT OF A FUTURE HIGH-SPEED CIVIL TRANSPORT (HSCT) AIRCRAFT FLEET ON THE ATMOSPHERIC OZONE COLUMN: A THREE-DIMENSIONAL MODEL SIMULATION

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Multi-year simulations have been conducted with the Langley Research Center (LaRC) three-dimensional, atmospheric Chemical Transport Model (CTM). The model vertical domain (24 levels) extends from the surface through the stratosphere. The model includes a comprehensive treatment of both gas phase reactions and heterogeneous chemical processes on polar stratospheric clouds (PSCs) and sulfate aerosol. Results from a model simulation that includes emissions from a mixed fleet of subsonic and supersonic aircraft with a route structure assumed for the year 2015 will be compared with results from two control simulations for the year 2015 (one assuming emissions from subsonic aircraft only and one assuming no aircraft). All three simulations assume the same background sulfate aerosol loading. The aircraft source emissions (NO_x, H_2O, and sulfates) used in the calculations are taken from a compilation of scenarios developed during the recent Intergovernmental Panel on Climate Change (IPCC) assessments. Results will be presented for the case of an HSCT fleet with an emissions index for nitrogen oxides equal to 5.0 grams per kilogram of fuel and assuming 50% of the fuel sulfur is converted to sulfate particles in the exhaust. Discussion will focus on the the relative importance of the different chemical cycles that destroy ozone and the resultant seasonal and latitudinal perturbations in the column ozone resulting from the aircraft emissions.

ENVIRONMENTAL CONDITIONS FOR LONGLIVED CONTRAILS AS DERIVED FROM MOZAIC DATA

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The European project MOZAIC (Measurement of Ozone on Airbus In-Service Aircraft) provided during the last years a large set of near tropopause environmental data of temperature, ozone and water vapour. These have been subjected to a statistical analysis with the goal to define more precisely the environmental conditions in cases of persistent contrails. To locate such contrails in the very frequented transatlantic flight corridor NOAA satellite quick-looks of the eastern North-Atlantic were analysed for the summer period of 1995. The MOZAIC data of individual flight tracks correspond well to the ice cloud distribution inferred from these satellite images. Cloudy regions are in general connected with high moisture content around ice saturation and low ozone concentration, indicating the tropospheric origin of clouds. Although the measurement level of MOZAIC data cannot be guaranteed to coincide with the height of contrails observed in the satellite images, occasional overlap is suggested by the moisture record of individual flight tracks. These cases exhibit a systematically smaller ozone concentration than contrail free areas. Details of and possible reasons for these observations will be presented and discussed.

A POSSIBLE CHANGE IN CLOUD RADIATIVE FORCING DUE TO AIRCRAFT EXHAUST

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The radiative forcing of natural cirrus clouds from a reduction in the mean ice particle size is presented. The estimated reduction of the mean size in natural due to aircraft exhaust expected in the range between 10 and 30% based on measurements. The im However, the climatic forcing, the weighted sum of SW and LW forcings, depends on mean particle size, surface albedo and the ice water content. It appears that there is a range of diameters between 15 and 25 μm where the climatic response to a change

IN SITU MEASUREMENTS OF NOX IN THE NORTH ATLANTIC FLIGHT CORRIDOR

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Aircraft emissions are a major source of nitrogen oxides in the upper troposphere and lower stratosphere. They are of particular importance due to their potential to modify the net ozone production rate there. In situ measurements of nitrogen oxides in the upper troposphere of single research flights are affected by the high variability of the nitrogen oxides abundance in this region and represent no adequate data base for comparison with simulated NOx fields from models.
Here a data set is presented that comprises more than 30 measuring flights which were performed between July 1994 and July 1996 in the Flight Corridor over the North East Atlantic. For the measurements the DLR research aircraft "Falcon" was used, equipped with NO, NO2, and O3 detectors. A significant seasonal dependence of the nitrogen oxides abundance was found in the upper troposphere. Mean NOx values range between 120 and 280 pptv and 50 and 140 pptv in summer and winter, respectively.
The measured NOx abundance is compared to NOx fields predicted with the general circulation model ECHAM, which was extended by a linear NOx chemistry module. It is found that predicted NOx values compare fairly well with measured NOx values both for summer and winter conditions.

ST17 Aviation and space flight (co-sponsored by OA)

02 Air traffic meteorology and weather impact on aviation

Conveners: André, J.-C.; Hauf, T.
Co-Conveners: Carriere, J.-M.; Corjon, A.

ANALYSIS OF THE MICROPHYSICAL DATA IN THE EURICE DATA BASE.

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Aircraft icing remains a significant aviation hazard, especially for turboprop aircraft, and rotocraft because of the lower altitude at which they operate. The EURICE project, partly funded by the EC, has been running for two years. This is aimed at examining current aircraft icing problems and the related certification process.

As part of EURICE, a data base of microphysical measurements has been established by the Project Co-ordinators, CIRA. The data base contains 7000 nm of measurements from the EURICE partners, plus 28000 nm gathered by the FAA. The liquid water content (LWC) measurements cover the range 0 - -39°C and 500 - 25600 feet. The variation of supercooled LWC with altitude, temperature and extent is described briefly in this paper.

An important part of EURICE is the consideration of the accuracy of the current Appendix C icing atmosphere. Results will be presented of a detailed comparison between the microphysical data and Appendix C. Only drops to 50 microns diameter are considered as in the current Appendix C. It is shown that the data are in excellent agreement with the Appendix C supercooled LWC vs. median volume diameter characterization for both stratiform and convective cloud. Poorer agreement will be shown with the Appendix C altitude vs. temperature icing envelope. Finally, the applicability of Appendix C to conditions below 10,000 ft is considered briefly.

Expected Performance of Crosswind-Based Wake Vortex Avoidance Systems at DFW Airport

D. Burnham & R. Rudis

Relaxation of wake vortex separation standards is possible when the ambient crosswind is within certain limits. The feasibility of a wake vortex avoidance system (WVAS) based on such limits depends upon (1) how often suitable crosswinds occur, (2) how long the conditions last, and (3) whether separation changes can be forecast. The paper will analyze five different crosswind-based WVAS, which address landing, takeoff, single-ruwway and close-spaced-parallel-runway operations. The analysis uses minute-by-minute wind data collected at the Dallas-Ft. Worth Airport.

THE INFLUENCE OF ATMOSPHERIC TURBULENCE ON CROW INSTABILITY INITIATION

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The sinusoidal instability known as the Crow instability is an essential factor affecting the disintegration of the vortex wakes. This instability should be taken into account in the wake vortex decay model intended for the investigation of the second airplane dynamics. The initiation of the Crow instability due to atmosphere turbulence and variable wing loads is considered in the some publications in which the lifespan of a vortex time is estimated. In this investigations it is supported that the wake vortices disappear when the amplitude of vortex line deviations from an initial position becomes equal to the initial distance between them. There are a number of experimental work in which the vortex lifespan is estimated at different turbulence levels. To investigate the second airplane dynamics it is necessary to know not only the lifespan of a trace, but also a spatial position of vortex lines. This position is a random process, the characteristics of which depend on many factors, mainly on atmospheric turbulence. The purpose of this paper is to determine the characteristics of this process. These characteristics can be used to construct an algorithm which generates random realizations of the wake vortex position in space. Such an algorithm can be used for the investigation of the second airplane dynamics.

"SY.A.G.E. - The French Wake Vortex Spacing System" P. Caisso and J.C. Valentin and A. Corjon

The STNA (Service Technique de la Navigation Aerienne) is performing studies on wake vortices since 1992 for the DGAC (Direction Generale de l'Aviation Civile). Due to limited budget, the work progress is not as fast as expected. In this paper, we will present SY.A.G.E. (SYsteme Anticipatif de Gestion des Espacements). This system intends to optimize the separation between aircraft at landing and take-off. All the developments done in France are related to this definition.
A first version of SYAGE has been set-up and an experiment aiming at operationaly verifying the system is presented. This first version concerns aircraft at departure and crosswind considerations. Then a windline of seven anemometers has been installed on Toulouse-Blagnac airport to monitor the position of the vortices. This trial should assess the needed accuracy on the wind measurement for an operational system. The constituted wind database will be used to develop short term forecasting compulsory to have the landing version of SYAGE.

COMPARISON OF LABORATORY WAKE VORTICES WITH AIRCRAFT VORTICES

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Measurements of wake vortices from both laboratory models and aircraft will be presented. The laboratory measurements were obtained in a water-filled towing tank using model wings. Vortex evolution in the laboratory is followed from generation through decay in three stages: (1) a 2-D line vortex pair, (2) transition from 2-D line vortices to 3-D vortex rings, and (3) development, migration, and decay of vortex rings. The laboratory experiments use both dye (for visualization) and neutrally-buoyant particles (for both visualization and DPIV measurements of circulation). We will present measurements in both nonstratified and stratified flows to show the effects of stratification. Measurements of aircraft vortices, obtained as part of NASA's AVOSS Wake Vortex Program, will also be presented. Simultaneous meteorological measurements will be used to interpret the aircraft wake vortices in terms of nondimensional parameters. We will compare vortex transport and decay from the laboratory and aircraft measurements both to each other and to a modified version of a wake vortex prediction algorithm originally reported by Greene (1986).

Computational Investigation of Aircraft Trailing-Vortex Evolution in Atmospheric Boundary Layers.

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This paper presents three-dimensional large eddy simulations (LES) of civil-aircraft trailing vortices in different realistic atmospheric boundary layers (ABL) with a non-hydrostatic meteorological model. These calculations were performed in order to parametrize an operational model aiming at managing the separations between aircraft at take-off and landing. The problems considered here are taken from twelve selected cases corresponding to trials made at Idaho Falls sponsored by the Federal Aviation Administration (FAA) in 1990. During these trials there was two prevalent meteorological conditions: stable boundary layer and turbulent convective boundary layer. The three-dimensional behavior of the wake vortices (Crow instabilities) as well as the effects of the atmospheric parameters (turbulence, lateral wind, stratification) are discussed. The results of the simulations are compared to experimental data.

AMETIS1 SYSTEM FOR WINDSHEAR AND INVERSION WARNINGS AT THE ZURICH-AIRPORT

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Wind shears and inversions are especially during landing or take off a meteorological danger for the aviation. AMETIS1 (Aeronautical METeorological Information System) is a ground-based observing system which collects temperature, dew point and wind data from several surface stations at different heights on hills surrounding Zurich airport. With these data wind shear and inversions are calculated and displayed on a screen in color depending on the degree of danger for aviation. If defined threshold values are reached or passed, an acoustic signal is emitted and a wind shear or inversion warning is issued.
Since 1988 AMETIS1 is operational and data from exceptional weather situations concerning wind shear or inversions were collected and analysed. An example for a weather situation with wind shear is the foehn wind that reaches the airport aera and produces wind shears of 8 KT in a layer between 1450 ft/GND and 2000 ft/GND and an inversion of 9° C between ground and 300 ft; another example for a strong inversion up to 16° C is a high pressure system during winter in a layer between 1450 ft/GND and 2300 ft/GND.

Impact of Adverse Weather on Major US Airports

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Adverse terminal weather is of particular concern at major US airports due to the very high traffic volume, the frequency of convective weather, air traffic operational procedures and airline scheduling procedures. This paper summarizes lessons learned in 10 years of experimental terminal weather information system operations at major US airports, including Dallas/Ft. Worth, Orlando, Memphis, Kansas City, Denver and San Francisco. We review first the implications of the overall air traffic management philosophy used in the US in creating sensitivity to adverse terminal weather. Recent results in the area of safety (especially windshear, gravity waves, downbursts, and CAT near storms) are described, including statistics on the relationship between microbursts and days with thunderstorms. We then discuss the impact of convective weather and low ceiling/visibility on delays and operational efficiency. It is shown that a significant fraction of the delay is "avoidable," given better weather and air traffic management decision support tools. The paper concludes with a summary of implications of the US experience for European airports.

Reducing the Impact of Adverse Terminal Weather on Major US Airports with the Integrated Terminal Weather System (ITWS)

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Adverse terminal weather is the major cause of delay at major US airports as well as a significant safety hazard. A fully automated terminal weather decision support system has been developed which combines data for ground and airborne weather sensors as well as national numerical models to provide products which can be directly used by controllers, pilots, traffic flow managers, terminal facility supervisors and automation systems. The current products include predictive wind shear information, storm tracking and extrapolation, storm severity and high resolution gridded winds to improve aircraft sequencing and merging. Operational use of functional prototypes at three major US airports (Dallas, Orlando and Memphis) has shown that delays due to convective weather can be substantially reduced and that better terminal winds information can improve aircraft merging and sequencing during adverse weather. The greatest convective weather delay reduction benefits were found to arise from improved traffic flow management decision making. The paper concludes with a summary of current research underway to further extend the safety and efficiency (delay reduction) benefits.

EFFECTS OF WEATHER ON AIRCRAFT WAKE TURBULENCE EXPERIENCED DURING CRUISE FLIGHT

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Weather effects on aircraft wake turbulence in the terminal area are a current topic of international research. Due to recent reductions in vertical aircraft spacing over the north Atlantic ocean, there is increasing international interest in the effects of wake turbulence during cruise operations. This paper presents an analytical study of the effects of weather and aircraft size on the potential for wake turbulence in cruise. A simple model of wake motion and decay is used to estimate the effects of winds, atmospheric turbulence, and temperature lapse rate on the maximum distance which a wake might descend. An estimate is also provided as to whether or not the wake remains coherent or descends as a series of crude rings due to the Crow Instability. The wing span of the generating aircraft is show to be a critical parameter in addition to the weather.

PARTICIPATION OF METEO-FRANCE IN WAKE VORTICES STUDIES

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In order to reduce aircraft separation standards defined by ICAO, Meteo-France has developed different wake vortices studies, as requested by the STNA (« Service Technique de la Navigation Aérienne »). In the first study, the effect of crosswind on wake vortices trajectory is analysed by using the VORTEX model, developed by CERFACS (« Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique »). This model allows real-time evaluation of hazards associated with the wake vortices. The work has led to the definition of crosswind classes related to hazard duration, which corresponds to the time the two vortices stay inside the safety corridor (defined as the range ± 45 m from the runway axis). These classes depend on the number of runways and their distance. Regarding the configuration « separation of 3NM on independant runway », two classes of crosswind are needed: smaller than 3 $m.s^{-1}$ and larger or equal to 3 $m.s^{-1}$. The second study analyses the evolution of wake vortices at small scale in 2D by using the French Méso-NH model, an atmospheric simulation code developed in cooperation between Meteo-France and the CNRS (« Centre National de Recherche Scientifique »). This model is initialised with the Idaho Falls experiment data. Different crosswind, stratification and wind profile are simulated for stable and mixed convective boundary layer. The work on the crosswind leads to about the same classes as with the VORTEX model. The VORTEX model could be improved in a further step by using the results on stratification and windshear.

WEATHER IMPACT ON THE AIR TRAFFIC IN THE THREE AIRPORTS OF GALICIA (SPAIN)

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Galicia is the Spanish region placed in the Northwest of the Iberian Peninsula. There are three international airports in the region placed in Vigo, Santiago and La Coruña. The aim of this study is to know the meteorological patterns that have produced problems in their air traffic in the last five years, to classify these patterns, to evaluate the cost/pattern for different air companies and to study the beneficts that an improvement in the nowcasting could have produced.

VORTEX WAKE MEASUREMENT TEST RUN FACILITY SCHIPHOL

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The flow field downstream of the Test Run Facility at Schiphol Airport was measured to obtain detailed and quantitative data on the vortiex wake. It was found that this wake was characterised by two strong vortices and a large velocity defect. The facility, which consisted of 16 m high walls, is located at 330 m sideways from the eastern threshold of runway 27. Under quartering headwind-conditions the wake of the building crosses the approach path. The tests were initiated as a result of pilots reporting not only elevated turbulence levels but occasionly also speed loss and aircraft bank. As these perturbations were experienced during the final approach phase, restrictions were issued on the use of runway 27 under certain wind conditions. The measurements, directed towards reducing the wake-disturbance, were performed in the DNW-LST 3*2.25 m^2. The downstream development of the flow was measured by means of a scanning 5-hole tube rake, enabling a rapid measurement of the velocity vector field in a cross-section behind the model. Turbulence data were also obtained at some positions. It was found that the concentrated wake was lifted by the action of the vortices, although the latter were found to decay rather quickly, probably due to dissipative action of the viscous wake. The results have been used as input to some first flight-simulator studies. These suggested that the perturbations to the aircraft motion, as experienced in practice were caused primarily by the velocity defect in the viscous wake and not by the vortices. The study lead to a lowering of the walls from 16 to 6 m.

Analysis of Stalled Vortices at DFW Airport

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Separation standards for final approach must account for the possibility that a wake vortex generated by a preceding aircraft may, because of interaction with the ground and the ambient crosswind, stall in the glide path. A ground-based array of anemometers was used extensively in the 1970s to detect stalled vortices. An array also gives measurements of the ambient wind close to the location where the vortices lateral motion is measured. Data recently collected at Dallas-Ft. Worth Airport are analyzed and compared to the 1970s results. The analysis concentrates on the arrivals when atmospheric turbulence was low to optimize the vortex detection and to select conditions when long vortex lifetimes can be expected.

AIRCRAFT WAKE VORTEX CHARACTERISTICS IN THE STABLY STRATIFIED ATMOSPHERE

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Aircraft wake vortices (WVs) may exert a serious danger on a following aircraft if the separation between the leading and following aircraft is not sufficient. In view of the expected growth of air traffic, increasing demands on the capacity and safety of international airports have to be faced. A promising approach to increase the capacity of airports is to model the temporal evolution of WVs in order to forecast their lifespan.

It is meanwhile generally accepted that meteorological conditions such as turbulence, stratification and shear dominantly determine the development of WVs. We focus on the impact of the stably stratified atmosphere, an issue which has been discussed controversly since years. Based on 2-D and large eddy simulations as well as simple vortex element methods the behaviour of WVs is analysed. Depending on the degree of stratification we observe both an accelerated and a decelerated descent of WVs. Both effects are explained by the interaction of the WV's flowfield with vorticity produced due to baroclinicity.

THE PREDICTION OF VERY SHORT PERIOD CROSSWIND SPEED USING STATISTICAL TECHNIQUES.

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Any future wake vortex advisory system needs to have the capability to predict the strength of the crosswinds affecting aircraft in the vicinity of the runway. Wind measurements are routinely taken at all airports and these measurements are available to the pilot through air traffic control. This is problematic since it is unlikely that the measured wind speed would be appropriate to the precise time and location of the aircraft on either final approach or after take-off.

It is known that the use of persistence gives a reasonable forecast of wind speed over short time periods or short distances although the use of predictive statistical techniques can reduce forecast errors quite markedly.

This paper describes the use of various techniques for crosswind prediction as applied to a large sample of one-minute reading taken at Memphis airport during 1995. Results are presented showing the improvements in forecast accuracy that can be gained through the use of these techniques.

SIMULATION INVESTIGATIONS INTO AIRBORNE REACTIVE AND FORWARD LOOKING WINDSHEAR DETECTION SYSTEMS.

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The paper to be presented outlines the results of the Flight Mechanics 5th Action Group of the Group for Aeronautical Research and Technology in EURope (GARTEUR). The aim was to have a better understanding of the behaviour of a transport aircraft under windshear conditions, and the improvement in flight safety that can be achieved by using an airborne windshear detection system. Some results from an inquiry held amongst European airlines to inventory their experience with occurrences of windshear events are reported. A complete non-linear numerical simulation was set up in order to analyse the aircraft response during windshear encounters at approach/landing and take-off. The generic aircraft was assumed to be equipped with a fully automated flight guidance coupled to an airborne windshear detection system such as reactive and forward looking system (FLS). The windshear scenarios were selected from existing models providing realistic wind situations. The investigated atmospheric threats were the downburst/microburst situation and the low-level jet. The simulation environment was designed to perform a parametric study on various factors such as specific characteristics of a forward looking windshear detection system of the Doppler-lidar type, severity factors, intensity and location of windshear. Some basic results are presented to show the advantage of a forward looking windshear detection system, compared to a reactive system. With an advance alert-time of more than 20 s the fully automated system has the potential to improve aircraft safety, even in case of extreme windshear conditions. But the most promising concept seems to be a combined use of reactive and FLS.

OBSERVATIONS OF AIRCRAFT ICING AND SUPERCOOLED LARGE DROPS

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During the EURICE flight campaign March 1997 a DLR DO-228 research aircraft made five flights over Southern Germany in supercooled clouds. The aircraft was equipped with optical cloud probes (OAP 2DC, FSSP 100, FSSP 300), a LWC probe, a temperature sensor and an icing cylinder with video documentation. The measurements took place in mixed-phase stratus clouds and stratus with embedded convection. Cloud top temperature was at about -5° C. Maximum icing rates of 3.5 mm/min together with drops in the size range 50 - 200 µm (SLD) were found frequently and on spatial scales ranging between several hundred meters and several kilometres. Ground-based radar observations show clearly that these SLD events occurred whenever the aircraft penetrated one of the embedded convective cells. SLD were found at all heights but seemed to be more frequent near cloud top where also maximum LWC values were found. A physical picture of the SLD mechanism will be developed and implications for the aircraft icing problem will be discussed. A video clip shows the growth behaviour during SLD events and for standard icing.

IN-FLIGHT ICING CLOUD MEASUREMENTS BY AN AIRBORNE DROPLET ANALYSER

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CIRA experimental involvement in EURICE project for severe icing conditions research in the atmosphere concerned the participation to the flight test campaign conducted in March 1997 in The Netherlands on NLR research aircraft. CIRA contributed to the flight tests with the utilisation of an optical probe based on Phase Doppler measurement technique for the individuation of droplets diameter distribution in the clouds. So on an Airborne Droplet Analyser (ADA) has been developed and installed on NLR aircraft with the main aim to be able to detect droplets in a range between a few until 600 and more microns. During three flights the probe acquired droplets of different diameters with presence of sparse large droplets; diameter distributions have been correlated with altitude and air static temperature during each of the three flights. Median Volume Diameters and Liquid Water Contents have been calculated for shorter time interval when the cloud characteristics and the data rate allowed to have a consistent number of droplets acquired. The results obtained have been analysed in order to compare data to FAR 25 App. C icing certification requirements and to foresee tests conditions for performance degradation research in icing wind tunnel facilities.

SUPERCOOLED LARGE DROPLETS IN ICING CONDITIONS

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In March 1997 NLR investigated the icing atmosphere for aircraft by flying with an instrumented research aircraft through clouds. Liquid water content, droplet diameter distributions and air temperature were measured. Large droplets were found in air masses with a limited extent. Results from the measurement campaign are presented. Implications of ice accretion on helicopters and fixed-wing aircraft due to large droplets are discussed. The investigations were part of the project EURICE, a co-operation between aircraft manufacturers, research institutes, civil aviation authorities and universities.

COMPARISON OF ASR WEATHER CHANNEL ECHO AND 3 D LIGHTNING OBSERVATIONS IN FLORIDA STORMS

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Precipitation radar echo of a Florida storm is provided by the weather channel of an Airport Surveyance Radar. ASR delivers a vertical integrated echo of precipitations. The 2D storm cells described by this radar are compared with 3D lightning location provided by a high resolution VHF interferometer. We discuss how interpretation of informations on storms from a simple weather radar device can be improved by a detailed description of the lightning activity. Application of this concept to Air Traffic Management support is also discuss.

WAKE VORTEX HAZARD DETECTION DOPPLER LIDAR

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The performance of an airborne, wake vortex detection system is investigated by simulation. The proposed detection system uses a forward looking, pulsed Doppler Lidar to interrogate the intended flight path of the aircraft. It aims to give advance warning of any hazardous wake vortices, generated by preceding aircraft, that enter the aircraft's intended airspace. Any Doppler system is only capable of resolving velocities in the direction of the emitted wave. Thus, the proposed system aims to detect hazardous wake vortices based on axial characteristics.

Realistic wake vortices are simulated in a convective atmospheric boundary layer using a three-dimensional Large Eddy Simulation model. The simulation is initialised with data collected during trials made at Idaho Falls by the Federal Aviation Authority in 1990. The evolution of the vortices in characteristic atmospheric conditions is then calculated. At discrete stages in the evolution, the computed flow field is applied to the Lidar system simulator. The Lidar system simulator models the shot noise limited Lidar, the atmosphere and the signal processing, outputting the set of line of sight velocities that would be measured by a Doppler Lidar interrogating the given flow field. Pattern recognition techniques are used to detect any vortices. At each stage the hazard posed by any vortex in the flow field is estimated by calculating the rolling moment that it would affect on an encountering aircraft. If this rolling moment is of the same order as the rolling-moment capability of a commercial transport aircraft, then it is classified as a hazardous vortex. This paper aims to demonstrate that all such hazardous vortices can be detected using the proposed Lidar system.

AVIATION WEATHER IMPACTS ON AIR TRAFFIC MANAGEMENT

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Weather has a major impact on the capacity, efficiency, and safety of the air traffic management (ATM) system. Runway acceptance rates and other capacity metrics are reduced in instrument meteorological conditions. According to some studies, 40-65 percent of delays that impact U.S. domestic airlines are caused by adverse weather, at annual direct costs ranging from $4-5B per year. Passengers are inconvenienced by flight delays and cancellations or diversions due to weather, and are uncomfortable or may even be injured when turbulence is encountered during a flight. The expected future growth in air traffic will only exacerbate these conditions, imposing constraints on the ability of the industry to meet growing demand while improving safety and efficiency. The capability to observe, analyze, forecast, and disseminate weather information can be improved by recent technical developments, but the air transport industry lacks a consistent understanding of how to evaluate and use these new capabilities in the most beneficial way. The relative value of different types of weather products, the timeliness of their delivery, knowledge about the users and providers of aviation weather information, and other factors need to be understood to ensure that investment in technology development and operational systems provides optimum value. In this paper we present some of the findings from a study we are conducting to develop technical and business-relevant information on the impacts of weather on the ATM system, and on the role of weather information in emerging communications, navigation, and surveillance (CNS) technologies. We describe user requirements for aviation weather information, explain where operational deficiencies exist in the aviation weather system, and evaluate the impacts that emerging aviation weather technologies may have on improving efficiency and increasing capacity in the ATM system.

MORE INSIGHT INTO AIRCRAFT WAKE VORTICES BY MEANS OF GROUND-BASED CW DOPPLER LIDAR

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Aircraft wake vortices are presenting a potential hazard to other aircraft following closely behind. This is not only a safety problem but also a capacity problem at major airports. Several approaches are under investigation: A reduction of the presently binding separation distances can be achieved by long-range airfield systems or forward-looking onboard sensors for wake-vortex detection and warning. In the design phase of new aircraft types, mechanical features for vortex alleviation can be taken into account. Supposition for these approaches is the precise knowledge of the vortex properties and their temporal behaviour. At DLR, a cw Doppler Lidar has been developed for boundary layer wind measurements. This system is also used for the investigation of vortex properties, like velocity distribution, circulation, transport in ground influence and decay. During several field experiments, the signatures of a large variety of aircraft types have been acquired covering the bandwidth from small business to large commercial aircraft. Experimental data will be presented, including data of scarcely investigated vortices like those being generated by fighter-type aircraft and by helicopters. The relationship to aircraft parameters and to the atmospheric environment will be considered.

Developing the Real Time Verification System to Support Aviation Forecasting and Product Development

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This presentation will describe the Real-Time Verification System (RTVS) that NOAA Forecast Systems Laboratory (FSL) is developing to support aviation forecasting and product development. Verification of products (e.g., AIRMETs and SIGMETs) and the "guidance" forecasters use to generate those products is very important to the safety and efficiency of the airspace system.

FSL recently implemented the initial version of the RTVS at the National Weather Service (NWS) Aviation Weather Center (AWC). The version included capability to assess the quality of AIRMETs (icing, turbulence, and IFR conditions) and algorithms that generate forecasts of icing and turbulence. Based on feedback we gathered from AWC and the results of a previous assessment of requirements, we envision that the end-state RTVS will enable: 1) developers to assess the quality of algorithms for forecasting variables such as icing, thunderstorms, and turbulence; 2) program leaders and managers to assess the quality of algorithms and end-user products; and 3) aviation forecasters to assess the quality of the "guidance" available to help generate products for end-users.

FORECASTING TURBULENCE IN THE UPPER TROPOSPHERE

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At the Forecast Systems Laboratory (FSL), research is now in progress to develop and test diagnostic and prognostic turbulence forecasting algorithms to provide guidance for the aviation community. With the advent of reporting objective turbulence observations from aircraft, such as the vertical accelerometer and the in-situ dissipation rate data, it has been possible to begin development and verification of turbulence forecasting formulations that estimate, in a more physical way, those turbulence events that are dangerous to general and commercial aviation. A diagnostic algorithm (DTF5.0) has been developed to forecast turbulence from three sources: shear instabilities (in the boundary layer, and around upper fronts and jets), gravity wave breaking (e.g., mountain waves), and convection-related turbulence. Using the vertical accelerometer data, it has been possible to define a turbulence threshold, because approximately 90% of these reports correspond to no-turbulence, whereas >90% of the voice pilot reports (pireps) related the occurrence of turbulence. Verification statistics for the three components of DTF5.0 will be shown, including a discussion of seasonal and geographic dependencies. Results using the subjective and uncalibrated pireps will be contrasted with those from the objective measures (vertical accelerometer data and dissipation rate). Comparisons with a two-year set of statistics based on pireps for an earlier version of the diagnostic (DTF3.0) will also be made.

EFFECTS OF ATMOSPHERIC CONDITIONS AND GROUND PROXIMITY ON THE DYNAMICS OF AIRCRAFT WAKE VORTICES: A STUDY OF THE 1994-95 MEMPHIS FIELD MEASUREMENTS

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This paper studies aircraft wake data acquired by the MIT Lincoln laboratory and NASA Langley Research Center at the Memphis, TN international airport during December 1994 and August 1995. The objective is to identify the dominant mechanisms affecting the transport and decay of aircraft wake vortices. Specifically, the effects of atmospheric stratification, wind shear, atmospheric turbulence and ground proximity on the far-wake development are examined. The wake-vortex trajectories are observed to closely follow the ideal descent path under calm and near-neutral atmospheric conditions and away from the ground. Increased variability in the vertical wake trajectory is noted under high ambient turbulence (normalized turbulence levels in excess of 0.5) with observations of descending as well as rising vortices for the same turbulence energy. Interaction of the wake vortices with nonuniform ambient vorticity associated with a ground-jet crosswind profile is observed to arrest their vertical descent leading to a rebound. No discernible changes are observed in wake-vortex transport and decay over a normalized Brunt-Vaisala frequency range of 0.2 to 0.5. Wake-vortex rebound due to viscous ground interaction is observed to occur about one time unit after the arrest of the initial vertical descent. For wake vortices generated sufficiently close to the ground, the rebound is immediate. An effect of stratification on the rebound process is not observed over a range of normalized Brunt-Vaisala frequencies of 0.07 to 0.35. Furthermore, neither winds aligned with the wake axis nor wind shear in this direction appear to influence the rebound process.

ANALYTICAL AND NUMERICAL INVESTIGATIONS OF THE AIRCRAFT CONDENSING VORTEX WAKE

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The interest to the processes of atmosphere vapour condensation, particle creation and their subsequent agglomeration in the aircraft vortex wake is provided by the actual environmental problems. The aim of these investigations is to obtain simple precise formulae for the droplet and crystals concentration and mass fraction for certain physical regions and to compare them with the results of numerical research which have been carrying out parallel with the first. Condensation and aglomeration are considered on the "background" of the gasdynamical field of the vortices and jet of aircraft. Analytical approach include finding of self-similar solutions and the disturbances theory. In order to create a real model of a gas velocity field in the vortex wake a various turbulent models are used. They include also a self- similar low for the turbulent velocity coefficient. In conclusion an optical properties of aircraft condensing vortex wake are researched.
The work is supported by International Science and Technology Center, Projects #200, #1018.

INQUIRY INTO THE GROUND ATC/ATM REQUIREMENTS FOR METEOROLOGICAL DATA

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The aim of this inquiry is to access the actual and future needs for meterological information in the domain of ATC. The assessment has been achieved by sending a questionnaire to 24 European and non-European CAA organisations but also airports and Eurocontrol. This questionnaire was designed to find out the needs for new meteorological facilities as supplementary of information to french CENA inquiry which dealt with the needs of the controllers for meteorological information. This inquiry has tackled different thematics : data quality. meteorological phenomena. man machine interface. simulations and recording. new capabilities. prospectives thematics. ... .Answers analysis has revealed expectation for a better weather information. centralized on a common interface and particularly for storm forecasting visualization in order to increase safety. It appears that En-route flying requires turbulences and icing danger estimation. For accident/incident investigation. they asked for ability to exploit weather data recording. It appears that detection and tracking of thunderstorms requires a forecast period from 15 minutes to 3 hours. This inquiry has been funded by European Communauty for the project named 4MIDaBLE (« 4D Meteorological Information Data Base Linked across Europe ») in a consortium including Meteo France. UK Met Office. Sofreavia and Thomson-CSF which was responsible of the study of meteorological requirements for Air Traffic Management. We will present its results in this paper.

STORM FORECASTING WITH RADAR IMAGE PROCESSING BASED ON MODEL-CONSTRAINED & GEODESIC ACTIVE CONTOURS

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The aim of this study is to perform a short-term nowcasting of storm evolution (shape and position). Storms can be tracked by means of adapted algorithms based on new techniques such as geodesic active contours (front propagation) combined with (affine)model-constrained active contour for deformation prediction and topological change adaptation. The efficiency of our methods will be demonstrated on meteorological radar images. This application has one objective : civil traffic regulation according to severe atmospheric phenomenon. These works have been included in the European 4DMIDaBLE project.We will describe two main image procedures used for thunderstorm clouds tracking : geodesic active contours based on Hamilton-Jacobi formulation of curve evolving. and model-constrained active contour based on Euler-Lagrange formulation with affine deformable model. Finally. we will expose the new associate algorithmic chain for storm clouds detection and tracking. that manages topological changes and allows short term forecasting from 5 to 20 minutes of clouds deformation. The efficiency of our methods will be demonstrated on multisensor atmospheric images : radar (meteorological radar. meteo. channel of Airport Approach Radar), VHF interferometer (SAFIR) and satellite images (Meteosat). Correlation between SAFIR and Radar data has been demonstrated on real records.

A SUCCESS STORY BETWEEN NAV CANADA (Nation's provider of civil air navigation services) AND ENVIRONMENT CANADA.

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With the increase in the number of flights and the need to provide cost efficient weather services, the WWW has revolutionized NAV CANADA ' s means of providing this service. The level of popularity has surpassed expectations. The main goal was to increase the quality of service to pilots without an increase in operational costs. The option that was put to test : give the users the opportunity to brief themselves before contacting the Flight Service Station (FSS). As a result, consultation time has diminished and become more efficient. In this instance, the use of the Internet has succeeded in uniting major premises, bringing together data accuracy, efficient access and packaging information according to the users needs. Now both the pilot and the FSS briefer possess the crucial material required to conduct effective and safer exchange of information. The pilots'imputability has thus been raised considerably. The poster will display all aspects of this success story about providing better services to an increasing number of users without raising operational costs.

USER SENSITIVITY TO CEILING AND VISIBILITY AND ITS INFLUENCE ON TERMINAL FORECAST VERIFICATION

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The paper describes two distinct activities:
a) For transport aviation users sensitivity is measured by the cost to the user of a wrong forecast. The costs incurred to airlines in the use of optimistic and pessimistic forecasts of ceiling and visibility at the destination and diversion airports usually occur at the planning stage with respect to fuel loading procedures. The actual cost that results is affected by the decisions made by the captain of the aircraft at the various stages of the flight. For general aviation, although the sensitivity to particular meteorological parameters is quantified, it is not possible to derive an economic cost/benefit. The sensitivity is derived through questionnaires to GA pilots, flying clubs and flight briefing units.
b) Verification of Terminal Aerodrome Forecasts (TAFs) is not straightforward owing to the complex format in which the forecasts are given. A brief discussion is given showing that assumptions have to be made as to forecast interpretation before any verification scheme can be derived. An appropriate scheme is then selected that caters for user sensitivity.
Results of these two activities are combined to give a measure of the cost of inaccurate forecasts at a particular site. This cost is then compared with the costs incurred using a perfect forecast.

THEORICAL STUDY OF THE DRIZZLE FORMATION BY CO-ALESCENCE

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Supercooled drizzle is a meteorological hazard that can have fatal consequence for small airplanes because ice accretion can occur aft the protection area. The growing process for drizzle that cannot be explained by water phase change can be due to droplet coalescence. Especially, in the case of non convective clouds, the drizzle growth was observed to be related to a wind shear at the top of the cloud. We describe the evolution of the drop spectrum in term of a stochastic equation. The collision rate is determined for the shear turbulence flow. The hydrodynamic interactions and the van der Waals forces are taken into account. The stochastic equation is solved by the Kovetz-Olund method by using a quadratic finite element interpolation. The time necessary to form large droplets is calculated as the time of increase of the median volumic diameter. This time is compared with experimental observations.

INVESTIGATION INTO LIGHTNING STRIKES TO HELICOPTERS OPERATING OVER THE NORTH SEA

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A preliminary study to investigate lightning strikes to helicopters operating over the North Sea showed that on a significant number of the events the pilots reported no previous lightning activity to be present. This led to the hypothesis that the helicopter triggered the lightning strike as a result of its presence at that point in space and time. This study set out to investigate the meteorological conditions surrounding the lightning strikes. Eleven incidents dating back to 1992, have been studied. Data has been extracted from Met. Office archives for the dates and times of the incidents. The analysis of the synoptic data (synoptic charts and satellite pictures) showed that in all eleven cases being studied, cumulonimbus (Cb) clouds were in the vicinity. This information is not strictly in contradiction to the previous study in that the Cbs may not have started producing lightning until the helicopter flew into it. It is true to say, however, that large charged regions will have developed within these Cbs.
A null data set was generated from dates, times and locations when similar Cb clouds were present alongside helicopters and a lightning strike didn't occur. The meteorological data from this null data set was then compared with the meteorological data from the eleven strike incidents that are being studied in depth.

NEW METEOROLOGICAL DATA FUSION CONCEPTS FOR STORM NOWCASTING APPLIED TO ATC

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The objective of the development of new concepts for storm nowcasting is to provide in real-time to a meteorological data end-user such as the air-traffic controler a synthetic information about the storm evolutions which shall be sufficiently detailed and accurate to enable immediate identification and anticipation of hazardous phenomena caused by thunderstorms.
The synthetic information is based on the fusion of weather radar data and SAFIR total lightning activity data ; it benefits from the complementarity of these two informations for the identification of storm phases such as highly convective growth phase which perturbs the en-route traffic or intense precipitation downburst phase which can be hazardous in the terminal area.
Data fusion is performed on a pixel by pixel (1 km²) basis, using a two dimensional fusion matrix combining radar reflectivity and total lightning density, by setting classes directly related to the phase and intensity of the storm activity. It provides a synthetic map of hazardous storm areas, and gives to the end-users an information which is no longer a complex set of weather information, but represents the different cases of potential perturbation of the air traffic, and thus can be used for decision aid.
This approach shall be illustrated with air-traffic situations during the presentation.
The basic concepts were developed by Dimensions within the European project 4Midable (4D Meteorological Information Data Bases linked across Europe) funded by DGVII (Transports) of the European Union.

INFLUENCE OF WIND PREDICTION ON THE CAPACITY OF A TIME-BASED ATM SYSTEM

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With the fast growing air-traffic and stringent environmental regulations, the Air Traffic Management (ATM) system faces new demands. According to EUROCONTROL studies, a time-based ATM system could satisfy these demands. Within a time-based environment, the accuracy of the current arrival times prediction has to be improved in order to improve the capacity whilst maintaining the same level of safety (separation). This paper presents the results of a small scale experiment which investigated the influence of the current wind prediction on the accuracy of ground based arrival time prediction. Forty-two inbound flights to Schiphol Airport (The Netherlands) were executed under the condition of a constant speed and a continuous descent from an instructed top of descent (TOD). Arrival times were predicted with an algorithm using, amongst others, the speed and TOD instructions and the wind information. Arrival times calculated with the actual winds (as observed onboard the participating aircraft) instead of the predicted winds, showed an improvement in accuracy of approximately one-third. This indicates that under the condition of a constant speed and a continuous descent from an instructed TOD, the accuracy of the wind prediction has a large influence on the accuracy of the arrival times. From this experiment, it can be deduced that improved wind prediction is required to improve the capacity of a time-base ATM system. Further research should therefore focus on improving the wind prediction e.g. by using a data-link between the aircraft and the ground. With the data-link, meteorological information observed onboard the aircraft could be transferred to the ground, using the aircraft as a weather station.

GIANT SUPERCOOLED DROPS IN Cb

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During the summer of 1997 a Campaign was carried out in the Ebro Valley (Spain) to measure certain characteristics of storm cells. Three kinds of platform were used for observation: the Meteosat and NOAA satellite, a C-212 equipped with various kinds of sonde for measuring cloud microphysics, and, finally, a meteorological radar (Band C) with the TITAN and RDAS systems for data acquisition and processing. The study zone was a circular area of about 160 km in radius, centering on the city of Zaragoza. The proximity of the Mediterranean means that in conditions of thermodynamic instability, moisture spreads very quickly through the Valley.

A flight made on the 16 July 1997 was selected, because drops of this kind appeared in the interior of a storm cell, carried upwards by a strong ascending current (a maximum updraft >20 m/s was recorded). It was possible to see signs of ice-forming on the aircraft. The C-212 penetrated the cell from the right-hand southern. The temperature at the cloud base was +9ºC and the flight altitude was at -2ºC. The presence of a gigantic drop can be appreciated, which, if perfectly spherical, would have a diameter of 4637.4 um. On average, in the region where the increase in the volume of liquid water is most noticeable, the drops have a diameter of 715.5 um, which indicates that the small drops are scarce. After crossing various sections of the cloud, it was possible to see signs of ice-forming on the skin of the aircraft.

PROCEDURE FOR SCIENTIFIC FLIGHTS IN Cb

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Within the EURICE Program, in the Ebro valley an experimental procedure has been developed for the characterization of severe convective phenomena. Among the actions which have been carried out in the summer of 1997 we can point out the elaboration of a manual for flights inside the storm cells, to enable the penetration into those zones which are scientifically interesting for storms, minimizing the flights risks. The information provided by those flights has allowed us to progress in the knowledge of the characteristics of storms in a certain area of Spain, the Ebro valley, which is overflown by one of the most widely used air corridors in Europe.

DIAGNOSIS OF ICING AND NOWCASTING FOR AVIATION

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DIANA, a system for Diagnosing Icing conditions for Aircraft and Nowcasting for Aviation is under development at DLR in collaboration with the German Weather Service (DWD). Multiple data sources like conventional data, mesoscale model output, satellite and radar data together with pilot reports will be used to detect and nowcast regions where so-called "supercooled large drops" (SLDs) are likely to occur. SLDs are cloud droplets in the size range of 50 to 500 μm which can lead to rapid accumulation of ice on wings and tailplane if encountered by aircraft. As SLDs cannot be explicitly forecast, various icing algorithms implemented into the PennState/NCAR model MM5 provide a first guess of these regions. In a step by step procedure these generally overforecasted regions with icing conditions will be truncated by use of the AVHRR Processing scheme Over cLouds, Land and Ocean (APOLLO) developed by DLR. Radar measurements can be used to identify convective areas and freezing rain. Pilot reports will be used both for verification and improvement of the icing routines. Finally, after a testing periode, DIANA will be implemented into the routine aviation hazard warning service of the DWD.

Developing Grid Interaction and Product Generation Tools for NWS Aviation Forecasters

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This presentation will describe the effort by NOAA Forecast Systems Laboratory (FSL) to develop software tools that will enable National Weather Service (NWS) aviation forecasters to efficiently add value to (edit) high-resolution gridded Aviation Impact Variables (AIV) generated automatically by forecast models and post-processing algorithms. Examples of AIVs are icing, turbulence and clouds. The software tools will also enable graphical and text products to be efficiently generated from those value-added AIVs. The value-added AIVs, which will be made available to the aviation community via the NWS Aviation Digital Data Service (ADDS) and NOAAport, will also be appropriate for supporting FAA automation systems and free flight.

We are developing the software tools to run within the FX-Advanced meteorological workstation which is the basis of the National Weather Service (NWS) Advanced Weather Interactive Processing System (AWIPS). Initial versions of the tools are being evaluated at the NWS Aviation Weather Center in Kansas City, Missouri, USA.

AN AUTOMATED SCHEME FOR PREDICTING MOUNTAIN WAVE INDUCED TURBULENCE FOR CIVIL AVIATION

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Clear air turbulence (CAT) is a major meteorological hazard to aircraft, and is currently difficult to forecast with reliable accuracy. Apart from frontal effects and jet streams, the principle cause of CAT is mountain-induced gravity waves. These form as a result of stably stratified flow over mountainous terrain, and propagate upwards through the atmosphere. The turbulence resulting from breaking gravity waves constitutes a significant hazard to civil air traffic at cruising heights, particularly over midlatitude ranges in wintertime.

This report investigates the potential of gravity wave drag parameters from the UM to be used as an objective indication of mountain wave turbulence (MWT). Three case studies over the Alps are presented, where model data is compared with actual turbulence reports from civil aircraft. The three cases represent contrasting meteorological conditions over the same area.

The results show that the magnitude of the gravity wave stress vector is related to the frequency of positive turbulence reports, although more data is needed to quantify this further. These results will be used along with further studies to develop an automated operational system to predict areas and associated risk of MWT encounters at cruising altitudes across the globe.

AN OVERVIEW OF PROJECT SOCRATES

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Project SOCRATES is a research and development project aimed at addressing air safety and airport productivity through application of advanced technologies previously investigated for the U.S. Department of Defense. The basic premise is remote detection and localization of acoustic signatures from man-made and natural atmospheric turbulence. An acousto-optic technology is used to sense low frequency sound that has propagated from the atmospheric hazard to an optical sensing beam. This presentation will describe the basic sensing concept as well as the current effort to demonstrate concept feasibility for detection of sound generated by aircraft wake vortices. Results from measurements taken at JFK airport will be presented. Subsequent efforts to develop an array of sensors and the processing to achieve interference reduction and sound source localization will also be described. The long term view is to integrate this novel sensing technology with appropriate air safety systems to enhance overall capability and effectiveness.

ETWIRL: A NEW PAN-EUROPEAN WAKE VORTEX REPORTING SYSTEM AND DATABASE

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Increasing demands on European airport capacity has recently brought the issue of wake vortex hazards to the forefront of aviation research. However, current wake vortex separation rules take no account of the effects of meteorological conditions. With sufficient understanding of these effects, the potential to decrease separations under favourable meteorological conditions could be realised without compromising safety standards.

The European Commission has recently contracted aviation specialists RED Scientific Ltd. along with the UK Met. Office to implement a Europe-wide wake vortex incident reporting system, utilising both automatic and human data sources. The project, named ETWIRL (European Turbulent Wake Incident Reporting Log), will run for two years, and will develop a database of wake vortex encounters at European terminals along with comprehensive meteorological data.

This paper describes the expected content of the database together with a discussion about potential methods of data dissemination to interested parties. Confidentiality issues and the future role of the database will also be discussed.

ON THE SOUND GENERATED BY AIRCRAFT TRAILING VORTICES: A DESCRIPTION OF THE PROJECT SOCRATES THEORY AND MODELING EFFORT

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Results are presented of the Project SOCRATES Theory and Modeling study concerning the acoustic signature of aircraft wake vortices. The paper, which is an account of a work in progress, will focus on the examination of the physical mechanisms responsible for low frequency vortex-generated sound using a combination of analytical, computational and experimental methods. A lagrangian vorticity collocation method is used to compute the dynamics of columnar trailing vortices and Powell's form of Lighthill's acoustic analogy is used to compute the resulting sound field. Analytical results for a few canonical problems, such as the sound radiated by small amplitude core vibrations of infinite columnar vortices and vortex rings, are used to validate the numerical calculation of the acoustic field. Results of computational simulations will be shown for several model problems. Of particular interest for the wake-vortex problem is the sound field radiated by columnar vortices with periodic wrapped vortex rings which are known to form when strong coherent vortex structures interact with the relatively weak small scale structures embedded in the ambient turbulence. That interaction is expected to be a dominant sound radiating mechanism for trailing wake vortices. Computational and measured sound field characteristics will be compared in an attempt to support or refute that supposition.

COMPUTATION OF WIND EFFECTS IN THE WAKE OF BUILDINGS CLOSE TO A RUNWAY

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Large buildings close to a runway may cause wake disturbances that can influence landing and take–of conditions significantly. This is estimated by numerical flow simulations. A 3D finite element formulation is applied in the numerical model. The model is based on the Reynolds equations with a modified two–layer (K, ϵ) closure. Special wall elements are applied to implement the wall boundary conditions accurately. Realizations of the flow field along the runway are obtained by Monte Carlo simulations. Test results are provided by application to flow around a cube, with comparison to experimental and other numerical data.

An Interactive Aviation Weather Database (AWeD)

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A database of gridded aviation-impact variables has been created to be the core component of an aviation weather display system designed to be used as a briefing-aid tool. In its current state it includes: temperatures, winds, icing, turbulence, cloud fraction, relative humidity, vertical velocity, tropopause pressure and temperature, freezing level, total cloud cover, instantaneous precipitation rate at the surface and station pressure. The content of the database is generated from the operational Canadian Regional model outputs on a 35 km horizontal resolution grid, at 41 flight levels from the surface up to 40 000 feet, and at every 3 hours from zero- to 48-h projection time. The database is updated twice per day (00 and 12 UTC) in real time. The domain of the database covers all of Canada, adjacent waters and a significant portion of the United States. The current icing algorithm used is based on supercooled liquid water content forecast by the driving model. The turbulence algorithm is based on the deformation vertical shear index taking into account horizontal and vertical wind shear. Different other algorithms for icing and turbulence are also being tested. METARs and TAFs are available through the database and can be displayed in graphical format. The database is made accessible on network through a JAVA based graphical users interface. This application allows the users to enter flight parameters, such as departure and arrival airports, check points along the planned route, estimated elapse time of the flight and flight level. Series of meteorological products, all tailored to each particular flight, in plan view and vertical cross-section along the route, can then be generated and downloaded to the users. The system is thus fully interactive. A verification system is also under development as part of the database, in order to assess the reliability and performance of the different aviation impact variable algorithms.

OA18

INVESTIGATION OF A GRAPHICAL AREA FORECAST IN CANADA

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The Atmospheric Environment Branch of Environment Canada is examining a graphical area forecast (GFA) to communicate enroute aviation weather more effectively and precisely. The worded area forecast (FA) has been the primary source of enroute weather for general aviation in Canada and the US for over 50 years. The restrictions of text are often an impediment to effectively communicating the evolution and structure of clouds and weather. A graphical replacement overcomes many of these limitations and has become feasible with high speed telecommunications and powerful, affordable computers. Potential users have responded favorably and several formats have been demonstrated. The aviation community in Canada is currently being consulted to address outstanding issues of content, readability and geographical domain. The simplest solution is a computer drawing package to generate consistent readable products. A far more exciting possibility is to store the forecast information in a geo-referenced database from which a limitless number of information subsets can be extracted. These could be varying geographical domains or collections of weather elements at any point in time, displayed in two or three dimensional views. . It is also possible to automate production of corresponding worded FA,s. A database system can also facilitate more complete integration of observational data and numerical guidance into forecast production.

OA18 Heterogeneous and homogeneous chemistry of reactive halogen compounds in the lower troposphere (joint with ST)

Convener: Platt, U.
Co-Convener: Moortgat, G.K.

ACTIVATION OF HALOGENS VIA HOBr IN THE MARINE BOUNDARY LAYER - A LABORATORY STUDY

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Halogen activation, via uptake of HOBr on seaspray aerosol, is of great interest for the chemistry of the remote- and polar- marine boundary layer. Photochemically active species can be produced according to the following reaction scheme:

$$HOBr(aq) + Cl^- + H^+ \longrightarrow BrCl(aq) + H_2O$$

The BrCl product can (1) diffuse to the gas/liquid interface and enter the gas phase, where it photodissociates, (2) hydrolyse back to HOBr or (3) react with Br^- to form Br_2, which, in turn, may enter the gas phase.

$$BrCl(aq) + Br^- \longrightarrow Br_2(aq) + Cl^-$$

The efficiency (both relative and absolute) of conversion of HOBr to Br_2 and BrCl, depends on the chloride and bromide concentrations in the seasalt aerosol and on the aerosol pH. Laboratory experiments to investigate the interaction of HOBr with sythetic seasalt solutions were carried out using a wetted wall flow reactor / mass spectrometer combination. The results indicate that HOBr uptake onto aerosols with Br^-:Cl^- ratios encountered in the MBL results in predominately Br_2 production. The aqueous chemistry of the system studied was modelled using known equilibrium constants. The results showed excellent agreement with the experimental data.

MEASUREMENTS OF TROPOSPHERIC IODINE OXIDE IN THE MID-LATITUDES

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The role of reactive halogen species (RHS) in stratospheric ozone chemistry is well known today. The discovery of sudden tropospheric ozone depletion events in arctic spring, which were correlated with elevated bromine levels, woke the interest in tropospheric chemistry of halogens and halogen containing species. Following the measurements of Bromine Oxide in the Arctic in 95/96 the question arouse if there may be similar processes at mid-latidudes.
A field campaign in Mace Head / Ireland was carried out in the framework of the HALOTROP / ACSOE projects in April / Mai 1997. We present measurements of O_3, NO_2, SO_2, HCHO, HONO, BrO, ClO and IO by Differential Optical Absroption Spectroscopy (DOAS).
No spectral absorption of BrO or ClO could be identified during the campaign thus the concentration of BrO and ClO were below the detection limit. For the first time, however, it was possible to detect IO in the free troposphere. The characteristic absorption bands of IO between 427.6 nm and 436.4 nm could be identified during several days. The maximum IO concentration was 6.6 ppt (at a detection limit of 1.65 ppt). A calculation of the expected ozone loss with the measured IO concentration will be shown, also possible sources of IO will be discussed.

CHLORINE AND BROMINE DETECTION DURING ARCTIC OZONE DEPLETION EVENTS AT NY ALESUND.

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Reevaluation of the signals from the peroxy radical chemical amplifier, ROx-Box, obtained at the EC-sponsored Arctic Tropospheric Ozone Chemistry (ARCTOC) project revealed this instrument to be sensitive for Cl/ClO as well. During sunny periods the chemical amplifier signals often represent composites of peroxy radicals as well as Cl/ClO. The ROx-Box was calibrated in the following for active chlorine and the amplification mechanism was evaluated.
A few ppt of active chlorine appeared in boundary air ozone depletion events together with bromine oxide as followed by differential optical absorption spectroscopy (DOAS). Apparently both halogens were actively involved in ozone depletion during the campaigns at Ny Alesund, Spitsbergen, in April 1995 and 1996. The discussion will concentrate on the synergy of ozone destruction by bromine and chlorine and will be described by a chemical box model. The results for chlorine bring new insight in the mechanism of halogen release into polar boundary air.

A NEW LABORATORY APPROACH TO HETEROGENEOUS HALOGEN CHEMISTRY

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Dramatic ozone depletion in the Arctic boundary layer has been attributed to the presence of bromine radicals formed via heterogeneous reactions with the aerosol of the remote marine boundary layer. Presently the influence of bromine heterogeneous chemistry on the ozone budget of the less remote, more polluted boundary layer is being discussed. The new project started at Paul Scherrer Institute aims at quantifying the relevant reactions on tropospheric aerosol particles in the laboratory by making use of short lived radioactive isotopes (^{86,87}Br) with a half-life of 1 min. Such experiments basically allow the interaction of gaseous molecules with surfaces to be studied at arbitrarily low concentration. In a preliminary study the approach was successfully applied to a model system, namely by studying adsorption and desorption of HI to silver particles. The experiments showed that the interaction of the molecules with the particle surface can be described by an activated chemisorption process determining the low sticking coefficient of HI on silver. In a first application, the desorption of HBr from soot particles was studied to determine the binding energy of HBr to these particles. A broad distribution of chemically different adsorption sites for HBr on soot was derived from these measurements.

AN OVERVIEW OF OBSERVATIONS RELATED TO POLAR TROPOSPHERIC OZONE DEPLETION CHEMISTRY

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In the lower troposphere of the polar regions at sunrise, ozone depletion occurs. It is driven by halogen compounds, particularly those of Br and Cl. Evidence suggests that the source of these halogens are heterogeneous reactions that mobilize sea salt halogens in surface ice and snow. Since the early 1980s when tropospheric ozone depletion was first observed in the Arctic, there have been numerous observational studies of this phenomenon. The most recent have been a series of Polar Sunrise Experiments (PSE) at Alert Canada and the European ARCtic Tropospheric Ozone Chemistry (ARCTOC) project at Ny Ålesund/Spitsbergen. Other recent measurments indicate that tropospheric ozone depletion also occurs in Antarctica. Observational evidence of ozone depletion and related halogen chemistry is reviewed in this paper. In addition, a recently discovered link between the atmospheric cycle of mercury and arctic ozone depletion chemistry is explored.

C_2-C_7 hydrocarbon concentrations in Arctic snowpack interstitial air

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For the first time, samples of interstitial air from within the snowpack on an ice floe on the Arctic Ocean were collected during the 1994 Polar Sunrise Experiment. The concentrations of C_2-C_7 hydrocarbons were determined in Arctic snowpack interstitial air. Hydrocarbon concentrations tended to be higher than concentrations in free air samples above the snowpack, but ethyne concentrations in both interstitial and free air were highly correlated with ozone mixing ratios, consistent with previous demonstrations of the effects of Br atom chemistry. Results were inconclusive due to the limited number of samples, but suggested that there may be some differences in the chemical reactions occurring in interstitial air compared to the boundary layer. In this paper, we will compare air and interstitial samples and will discuss the potential chemical reactions involved in the snowpack and in the gas-phase.

GAS-PHASE KINETICS AND PHOTOCHEMISTRY OF BROMINE AND IODINE CONTAINING SPECIES IN THE MARINE BOUNDARY LAYER

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Recent field measurements have shown that reactive halogen species are ubiquitous to the marine boundary layer (MBL). A central role for bromine (Br, BrO and HOBr, Br_2 and BrCl) has been invoked to explain the well documented episodic depletion of ozone in the Arctic lower troposphere. In addition, measurements of photolabile iodine containing organics such as CH_2I_2 or C_3H_7I and the IO radical indicate that iodine may also play a crucial role in the ozone budget of the MBL. In the present study we present experimental, laser-based kinetic and photochemical results for the following processes:

HOBr + $h\nu$	→	OH + Br
BrO + DMS	→	products
HOI + $h\nu$	→	OH + I
HI + $h\nu$	→	H + I
OH + HI	→	H_2O + I
OH + C_3H_7I	→	Products

REACTIONS OF BROMINE ATOMS WITH ALKENES: KINETICS AND MECHANISMS AT LOW PRESSURE

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Autocatalytical active bromine release from ice or snow or sea salt aerosol may be important in the marine atmosphere at high or mid-latitudes (eg EC ARCTOC and HALOTROP project reports). The importance of this process is highly dependent on the formation rate and stability of the bromine reservoirs. Reactions of Br atoms with unsaturated hydrocarbons (alkenes) have been investigated as processes which may form bromine reservoirs in the marine atmosphere. The studied reactions include : Br + ethene, propene, trans-2-butene, 2-methyl-2-butene, 2,3-dimethyl-2-butene and 1-hexene.The mass spectrometry discharge-flow method has been used at total pressure = (0.5-2.0) Torr and over the temperature range T= (233-320)K. Both hydrogen atom abstraction (forming the HBr reservoir) and addition channels have been observed for these reactions and Arrhenius expressions have been obtained for all channels.The atmospheric implications of these results will be discussed.

THE REACTION OF ATOMIC CHLORINE WITH BENZENE

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It is now recognized that chlorine atoms may participate significantly to the oxidation capacity of the troposphere since atom concentrations ranging from 10^4 to 10^5 molecule cm^{-3} can be predicted, as a result of chlorine activation by heterogeneous processes. On the other hand, kinetic and/or mechanistic data concerning the oxidation processes of aromatic compounds are still rather scarce. The work presented here gives a new insight into the reaction of atomic chlorine with benzene, providing information both concerning reaction kinetics and mechanisms. The experimental work, performed using flash photolysis coupled to UV absorption was complemented by quantum calculations. The rate constant of the association reaction was investigated using the relative method and was found to be very low : $k(Cl + C_6H_6) = (9.8\pm4.1) \times 10^{-15}$ cm^3 $molecule^{-1}$ s^{-1}. In fact, no reaction could be observed in the absence of oxygen, and this lead us to conclude with the establishment of an equilibrium largely shifted towards the reactants Cl and C_6H_6 . This was confirmed by the theoretical calculations which showed that the chlorocyclohexadienyl radical, the addition product, was fairly unstable. As the abstraction channel, leading to HCl and the phenyl radical, is largely endothermic at room temperature (≈ 32 kJ mol^{-1}), it was considered to be inefficient. The reasons for such a slow reaction were not elucidated yet and work is still in progress.

OA18

WHICH COMPONENTS OF THE SEA-SALT AEROSOL PROMOTE THE Br^--CATALYSED PRODUCTION OF HALOGENATED RADICALS ?

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Former smog chamber experiments (Behnke et al., 1995; 1996), field experiments (Jobson et al., 1994; Singh et al., 1996) and model calculations (Mozurkewich, 1995; Vogt et al., 1996) show that halogenated radicals are produced in the presence of seaspray aerosol and ozone. A probable reaction pathway is that BrO is produced from the reaction of ozone with Br atoms; BrO reacts with HO_2 in the gas phase to form HOBr, which is adsorbed by the aerosol surface. In the droplets of the wet aerosol HOBr reacts with Br^- or Cl^- to form Br_2 or BrCl. The reaction should be dependent on the pH value and on the the ratio Br^-/Cl^-. Iodide may have an direct influence by catalysis. Sulphate and nitrate may have an indirect influence by changing the ionic strength of the aerosol.
Our smog chamber experiments show an initial phase with very low production rate of halogenated radicals, where a few Br atoms are produced by the known reaction of OH radicals with Br^-. A second phase is governed by strong ozone degradation promoted by the production of Br_2. In our recent experiments we show that, during these two phases, the ratio Br^-/Cl^- decreases from 1/600 to less than 1/2000. A parallel decrease of the pH value down to less than three is observed. This is caused by the uptake of oxalic acid produced from the degradation of hydrocarbons. Now begins the third phase of the experiments with a smaller production rate of Br atoms but high production rates of atomic Cl. Finally the production of halogenated radicals decreases. Previously we supposed that this decrease was caused by the loss of Br^- or an increase of the pH value. But our recent measurements show that the ratio of Br^-/Cl^- increases again to 1/1000 and the pH value decreases. So the cause of the decrease of the production rate of halogenes is unclear and requires further experiments.

KINETIC AND PHOTOCHEMICAL STUDIES OF IODINE OXIDE CHEMISTRY

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Halogen atoms and halogen oxide radicals X, XO where X=Cl, Br play an important role in the chemistry of the troposphere, through their participation in catalytic ozone destruction cycles. Iodine compounds have the potential to make a significant contribution to tropospheric ozone destruction, and have been proposed as a factor in mid-latitude stratospheric ozone reduction. A knowledge of the chemistry of I and IO, photochemical and kinetic data for reactions such as IO + IO, IO + XO, IO + HO_2, is necessary in order to quantify the possible role of iodine compounds in ozone destruction. The technique of laser photolysis / UV absorption spectroscopy featuring CCD detection has been used to investigate the chemistry of iodine monoxide. The absorption cross-section of the IO radical has been measured, and the kinetics of the IO + IO reaction studied as a function of temperature and pressure. OIO formation and loss in this system has been monitored, and a lower limit for the OIO absorption cross-section determined. The kinetics and products of the IO + BrO reaction have been investigated.

LABORATORY STUDIES OF THE UPTAKE OF ATMOSPHERIC TRACE GASES ON SOLID SURFACES

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Chemical interactions between gaseous trace gases and solid and liquid surfaces form an important part of atmospheric chemistry. The present project focusses on the experimental investigation of the fate of gaseous species (NO, NO_2, N_2O_5, HCl, HBr, HOCl and HOBr) on pure ice and frozen salt(acid)-solutions (NaCl, NaBr, HCl and HBr). The experiments were carried out using the coated wall flow-tube technique with the detection of gaseous species and reaction products by molecular beam QMS. Using the theory of transport and reactions in cylindrical reactors, we were able to derive the mass accommodation coefficients. The results will be discussed with regard to (i) adsorption equilibrium, surface reaction and saturation as well as (ii) the influence on the gasphase chemistry of the atmospheric trace gases in the presence of solid surfaces.

SPECTROSCOPIC AND KINETIC PROPERTIES OF XNO_2 (X = Br, I)

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Nitryl halides (XNO_2, X = Cl, Br, I(?)) are formed by the interaction of N_2O_5 with sea salt particles and can contribute to the radical budget in marine atmospheres. Spectroscopic and kinetic properties of these compounds are not well known. In this work, $BrNO_2$ and INO_2 were prepared in a 400 l photoreactor by photolysing $X_2/NO_2/N_2$ mixtures with light of 500 nm ≤ λ ≤ 700 nm at 1000 mbar. Long-path IR (50.4 m) and UV (3.13 m) spectra could be measured simultaneously using an FTIR and a diode array spectrometer. Photostationary concentrations of XNO_2 were established after ≈ 660 s and 240 s, respectively, for $BrNO_2$ and INO_2. The UV-VIS spectrum of INO_2 shows local maxima at 246, 286, and 345 nm and is red-shifted as compared to the UV spectra of $ClNO_2$ and $BrNO_2$. Absorption cross sections of $BrNO_2$ as determined from a mass balance of reaction (1), $BrNO_2 + NO \Rightarrow BrNO + NO$, are in excellent agreement with recent data of Scheffler et al. (1997). k_1 was measured between 255 and 293 K, resulting in $k_1 = 2.3\times10^{-12}\exp(-17.9\ kJ\ mol^{-1}/RT)\ cm^3 molecule^{-1} s^{-1}$. The observed stationary $BrNO_2$ concentrations suggest a rapid reaction between $BrNO_2$ and Br atoms. The long lifetime of $BrNO_2$ in the presence of radical scavengers supports the results of Frenzel et al. (1997) who suggested that the thermal lifetime of gaseous $BrNO_2$ is larger by four orders of magnitude than previous results of Kreutter et al. (1991).

KINETIC STUDIES OF THE REACTIONS OF THE IO RADICAL WITH ITSELF, $O(^3P)$ AND HO_2.

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Iodine-containing compounds, such as CH_3I, are released into the atmosphere from several natural sources, including oceanic plankton and the burning of biomass. There are also potential anthropogenic sources of iodine, such as CF_3I, proposed as an alternative fire retardant. Iodine atoms are released principally by the photolysis of alkyl iodides, their main fate in the troposphere being reaction with ozone to produce IO radicals. The kinetic results will be presented from laboratory discharge-flow studies of the reactions of the IO radical with $O(^3P)$, HO_2 and IO at room temperature, employing chemiluminescence and resonance fluorescence detection. The reaction of IO with HO_2 is thought to be important in the troposphere, and there are tentative suggestions that the reaction with $O(^3P)$ may occur in the stratosphere. The self reaction of IO is of little atmospheric significance, but is of interest to those observing the reactions of IO in the laboratory. Information on the overall rate constant and the branching ratios for the different channels will be presented.

KINETICS OF THE UPTAKE OF D_2O AND $BrONO_2$ ON ICE

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Ice forms a significant part of tropospheric and stratospheric clouds, and is therefore an important constituent of atmospheric aerosols. Because of the role of heterogeneous reactions in the destruction of stratospheric ozone, in which surfaces are involved, it is necessary to understand how processes such as cloud formation, growth, and trace gas interactions with ice occur in the atmosphere. Therefore, the real time kinetics of D_2O condensation and evaporation of D_2O on ice have been studied in a very low pressure reactor (Knudsen Cell) using MS detection. The kinetics of adsorption has a negative temperature dependence: the condensation coefficient γ of D_2O on ice decreases from 0.30 to 0.05 over the temperature range 140 to 220K. We found also a significant dependence of γ on the method of preparation of the ice. At 180 K γ= 0.23 for a bulk ice sample, whereas for condensed ice samples γ= 0.17 . These measurements revealed a complex mechanism of interaction of D_2O on ice, involving a precursor species.
In addition, considering the possible role of heterogeneous chemistry of bromine species in the springtime depletion of Arctic tropospheric ozone, we measured the uptake kinetics of Nitrate Bromine $BrONO_2$ on ice at temperatures of atmospheric interest both with and whithout HCl and HBr. Possible atmospheric implications of this work will be discussed.

Laboratory Kinetic Studies Of The Reactions Of Cl Atoms With Species Of Biogenic Origin.

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The reactions of Cl atoms in the troposphere, particularly in polar regions and the marine boundary layer, have received increased interest in recent years. Isoprene is one of the most abundant biogenic species in the marine boundary layer, so that its reaction with Cl atoms could prove to be significant.

Values of the rate coefficients for the reactions of atomic chlorine with isoprene and its atmospheric oxidation products, methacrolein and methyl vinyl ketone, have been determined both by a relative rate technique, using gas chromatography as the detection system for the organic species, and by an absolute technique, involving the use of a discharge fast-flow system with resonance fluorescence detection of Cl atoms.

The results obtained so far of the products determined by gc-ms will be presented for the Cl atom plus methyl vinyl ketone and Cl atom plus methacrolein systems.

REACTIVE BROMINE IN THE MARINE BOUNDARY LAYER: LABORATORY STUDIES OF GAS-PHASE AND HETEROGENEOUS PROCESSES.

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Reactive bromine species (Br, BrO and HOBr, Br_2 and BrCl) play a central role in episodic depletion of ozone in the polar lower troposphere and may be important for the remote MBL. HOBr links the gas- and aqueous phases where it takes part in ozone destroying catalytic cycles and in liquid phase reactions that convert Br^- to the insoluble, photolabile molecular halogens Br_2 and BrCl, respectively. In the present study, we have examined the efficiency of halogen activation via the heterogeneous reaction of HOBr on sea-salt aerosol (1a and 1b), made new measurements of the absorption cross-sections and J-values of HOBr (2), and made kinetic measurements of the reaction between BrO and DMS (3).

$HOBr + Br^-$	$\rightarrow$	$Br_2 + OH^-$	(1a)
$HOBr + Cl^-$	$\rightarrow$	$BrCl + OH^-$	(1b)
$HOBr + h\nu$	$\rightarrow$	$OH + Br$	(2)
$BrO + DMS$	$\rightarrow$	products	(3)

The relevance of these results to our present understanding of halogen chemistry in the MBL is discussed.

OBSERVATIONS OF ALKYL IODIDES AND BROMIDES AT MACE HEAD: LINKS TO MACROALGAL EMISSION AND IO FORMATION

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High frequency, in-situ GC-MS measurements of a range of biogenic short-lived alkyl halides in air including $CHBr_3$, $CHBr_2Cl$, CH_3I, C_2H_5I, CH_2ICl, CH_2I_2 and the hithero unreported CH_2IBr were made at Mace Head during a 3 week period in May 1997. Positive correlations were observed between $CHBr_3$ and $CHBr_2Cl$, CH_3I and C_2H_5I, and $CHBr_3$ and CH_2IBr throughout the campaign, providing evidence for common or linked biogenic sources. During periods when air masses were impacted by emissions from local seaweed beds, the concentrations of $CHBr_3$, CH_2ICl and CH_2IBr not only showed remarkable correlation but also maximised at low tide. These are the first field observations to provide evidence for a link between the tidal cycle and iodocarbon production. The total flux of iodine into the surface layer at Mace Head, calculated using the measured alkyl iodide concentrations, was found to be dominated by photolytic destruction of CH_2I_2. Photolysis of CH_3I contributed generally less than 5%. The peak iodine flux coincided with the highest levels of IO, measured by DOAS, during the campaign.

Modelling of low ozone measured at the West Coast of Ireland

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A boundary-layer measurement campaign was held on the West Coast of Ireland during the summer of 1996 as part of the UK programme 'Atmospheric Chemistry Studies in the Oceanic Atmosphere' (ACSOE). Periods of low ozone concentrations (e.g. 8-14 ppbv) were observed during the campaign. The Cambridge Tropospheric Trajectory model of Chemistry And Transport (CiTTy CAT) has been used to investigate both meteorological and chemical explanations for these observations. Back trajectories show the meteorological importance of the Azores high during these low ozone periods. This may offer a simple transport and chemical explanation for the low ozone: tropical air may be advected northwards with in-situ ozone destruction by photolysis and reaction of $O(^1D)$ with water vapour. Measurement of high concentrations of methyl iodide at the site concurrent with these low ozone episodes suggests the possibility that a loss mechanism involving halogens may in part explain these observations. These two possible explanations are evaluated.

SPECTROSCOPIC AND KINETICAL INVESTIGATION ON BRO APPLYING STATIC AND TIME RESOLVED RAPID SCAN FT-UV SPECTROSCOPY

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We present results of photolysis experiments with gas mixtures of Br2 and O3 in a cooled flow cell. A flash photolysis setup was used to initiate homogeneous reactions at stratospheric temperatures. Reaction products as well as intermediate species were observed by UV absorption measurements. A recently developed Rapid Scan method was used to achieve time resolved spectra. Synchronizing the flash photolysis experiment to the FT scan mirror we observed the dynamical processes in the reactions between Br and O3, yielding information about reaction kinetics. In addition, the FT-UV spectrometer was employed in static mode in order to record high resolution spectra of BrO at temperatures down to 213 K.

MECHANISTIC CONSIDERATIONS FOR TROPOSPHERIC HALOGEN ACTIVATION IN THE MARINE AEROSOL

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Results from laboratory and modelling studies of the formation and reactivity of aqueous phase free radicals which may be involved in the process of tropospheric halogen activation within the marine aerosol will be presented. Laser-based methods have been developed and applied for the generation and time-resolved detection of radical species. Modelling has been applied to discuss complications in the HOBr-based halogen activation process under low NO_x-conditions. By reaction of HOBr with HO_2/O_2^- in the aqueous aerosol, the non-radical halogen activation process may be accompanied by aqueous phase radical processes involving the bromine atom and the radical-anions $BrCl^-$, Br_2^- and Cl_2^-.
Contributions of reactions of the above-mentioned free radicals to the overall chemical conversions in the tropospheric marine aerosol will be discussed by means of the recently developed chemical aqueous phase radical mechanism (CAPRAM). This box model combines the well known gas phase RADM2 chemical mechanism with an extended set of aqueous phase chemical reactions taking into account numerous chemical reactions in the aqueous phase. An outlook on potential developments and open questions with regards to both modelling as well as future laboratory studies for understanding the marine aerosol halogen activation process will be given focussed on conversion processes in the aqueous phase.

OA18

MECHANISM OF NO_3 UPTAKE BY SOLID NaCl

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Chemical mechanism of NO_3 uptake on solid NaCl surfaces has been studied by means of matrix isolation/ESR (MIESR) and mass-spectrometry (MS) with variable level of electron impact ionization. The method of mobile rod covered by NaCl was used to infer main features of NO_3 uptake chemistry on solid and humidified NaCl. Three types of covering have been tested: 1. spirit solution spray, 2. water solution spray, 3. rod immerging in concentrated water solution and slow drying in air.
Low $[NO_3]=(3*10^9\text{-}5*10^{11}$ cm^{-3}) were studied with the MIESR technique while high $[NO_3]=(3\text{-}5)*10^{13}$ cm^{-3} were detected in MS studies. In MS experiments Cl atom was the primary product of heterogeneous reactions: (1a) $NO_3+NaCl=Cl+NO_2$ or (1b) $NO_3+NaCl=1/2Cl_2+NaNO_3$. ClO and NO_2 formed in reaction (2) $Cl+NO3=ClO+NO_2$ were observed and the balance of NO_3 consumed vs NO_2 formed was established. At low $[NO_3]$ reaction (2) is most probably suppressed by heterogeneous recombination of Cl atoms with liberation of Cl_2. In presence of H_2O vapor ($\sim 10^{-4}$cm^{-3}) HCl formation was observed. An attempt to explain the morning hydrocarbons' consumption, observed in Pacific Exploratory Mission has been done

REACTION RATE AND CHEMICAL MECHANISM FOR THE GAS PHASE REACTIONS OF Cl ATOMS WITH CH_2ICl AND CH_2I_2

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Iodinated compounds have been detected in the lower troposphere and in marine environments in the range of several ppt. They are mainly emitted by biogenic processes that occur in the marine boundary layer. Their tropospheric degradation mechanism is important in the understanding of the atmospheric chemistry of Iodine atoms. In general, iodinated compounds are very photolabile species and probably undergo efficient photodissociation in the troposphere. However, they may also react mainly with OH radicals, or probably with halogen atoms in marine environments where the concentration of halogenated species is high. This work studied the homogeneous reaction of Cl atoms with two iodomethanes of biogenic origin, CH_2ICl and CH_2I_2 at very low pressures, by using the Very Low Pressure Reactor (VLPR) technique. The absolute rate constants at room temperature were greater than 1×10^{-11} cm^3 molecule^{-1} s^{-1}, suggesting that both reactions occur via the formation of an intermediate weak adduct between the incoming Cl atom and the iodine end of the molecule. Mass spectrometric analysis of the reaction products revealed the appearance of ICl and HCl as final products, with no evidence of the I atom displacement reaction.

FIRST DOAS MEASUREMENTS OF TROPOSPHERIC BRO AT MID LATITUDES: THE DEAD SEA VALLEY AS A NATURAL LABORATORY

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In the mid 80th sudden boundary layer ozone depletion events were discovered in arctic spring. The simultaneously high BrO concentration awoke the interest in the sources and chemistry of halogen oxides in the troposphere. Recently the influence of BrO, ClO and IO on the mid latitude boundary layer chemistry was examined. Since sea salt is suspected to be a source of halogens, most of the investigations have been concentrated on coastal clean air sites like Mace Head (Ireland). So far no BrO has been found at low and mid latitudes.
In spring 1997 a campaign of the Hebrew University Jerusalem and the University of Heidelberg was performed at the Dead Sea. By using DOAS (Differential Optical Absorption Spectroscopy) and some other different analytical systems BrO and a number of other species, i.e. SO_2, NO/NO_y, CO, O_3 were measured. During a period of 4 weeks we observed repeating patterns of BrO and O_3. The daily variation of the concentrations showed high values of BrO correlated ozone depletion during late morning. The special morphological situation indicates the Dead Sea Valley to be a perfect outdoor laboratory to observe the influence of BrO on boundary layer ozone depletion.

LOW TEMPERATURE FTIR-STUDIES AND AB-INITIO CALCULATIONS OF BrOBr and BrBrO

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The reversible photoinitiated isomerization reaction of BrOBr to BrBrO was measured in solid argon matrices and calculated by multiconfigurational quasidegenerate perturbation theory (MCQDPT). The calculated vertical excitation energies are in good agreement with the experimentally observed excitation wavelengths.

While the isomerization from BrOBr to BrBrO appears to be quantitative, some product loss is observed during the back reaction. The calculated excitation energies and oscillator strengths for transitions from the ground to excited states offer a detailed explanation of this behaviour.

All three fundamentals of BrOBr and BrBrO could be observed. The previously unknown frequencies of the bending vibrations were located at 177.0 cm^{-1} for BrOBr and at 170.6 cm^{-1} for BrBrO. In addition the UV-spectrum of BrBrO has also been measured.

THEORETICAL AB-INITIO CALCULATIONS OF THE STRUCTURE AND STABILITY OF HALOGEN ATOMS ADDUCTS WITH ALKYL HALIDES

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There is growing experimental evidence that the reactions of alkyl halides with electrophilic groups, such as F and Cl atoms, occur via the formation of an intermediate adduct between the incoming group and the electron-rich site of the halide molecule. The present work has performed systematic theoretical calculations in order to elucidate the relation between structure and stability in a series of the adducts between F and Cl atoms (X') and several substituted bromo- and iodo-methanes (RX). The ab-initio calculations were performed at the MP2/3-21++G(2d,2p) level of theory for all species, and were repeated at the MP2/6-31++G(2d,2p) level for the adducts of bromomethanes. The structure of these adducts was generally characterized by very close R-X-X' angles (ca. 80 degrees) and minor perturbation of the structural parameters of parent halide molecule. The depth of potential well of the RX-X' interaction was found to depend upon the relative electronegativities of the two halogen atoms X and X', and was deeper for the RI-F adducts (ca. 100 kJ mol^{-1}), while the degree of halogen atom substitution on the carbon atom was found to decrease the potential well. Vibrational frequencies of all species were calculated and the corresponding reaction enthalpies and the X-X' bond strengths of the adducts at 0 K and 298.15 K were also derived.

THE Cl ATOM OXIDATION OF ISOPRENE STUDIED IN THE LABORATORY

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The reaction of Cl atom initiated oxidation of isoprene (CH_2=C(CH_3)-CH=CH_2 or C_5H_8) is of potential importance in the marine atmosphere, where both Cl atoms and isoprene can be simultaneously present. The chlorinated oxidation products from this natural source may influence the tropospheric budget of chlorinated species. In relation to this issue, the kinetics and mechanism of the Cl + isoprene reaction has been investigated. The rate constant of this reaction has been determined as function of temperature and pressure using two complementary methods: discharge flow-mass spectrometric and laser photolysis-resonance fluorescence. The main value obtained at 298 K is k(Cl + isoprene) = (3.5 ± 0.1) x 10^{-10} cm^3 $molecule^{-1}$ s^{-1}. Besides, the discharge flow study showed evidence for two channels: addition of Cl atom and HCl elimination. The HCl yield was measured as function of temperature and found to be 0.17 ± 0.02 at 298 K. The atmospheric implication of these data will be discussed.

TROPOSPHERIC OZONE DEPLETION AND RELATED HALOGEN CHEMISTRY AT POLAR REGIONS

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Since one decade the phenomenon of tropospheric ozone depletion during spring has been reported from several Arctic stations and recently also from Neumayer, the German overwintering station in Antarcica. Simultaneously to tropospheric ozone loss enhanced levels of BrO (measured by DOAS) and f-Br (non sea salt bromine collected on cellulose filters) could be observed. While the mechanism of ozone depletion seems to be caused by a chemical reaction cycle including free halogen radicals and halogen oxides, the source of these reactive halogen species is still unclear.
In our presentation we will summarise our continous ozone. DOAS and aerosol filter measurements of two field campaigns in the framework of the EU project ARCTOC during spring '95 and '96 at Spitsbergen/Arctic. We will give an interpretation of the coupling between observed ozone and halogen species (i.e. BrO and f-Br), which is consistent with the proposed autocatalytical recycling of reactive halogen species.
With the help of ozone and halogen data from the Neumayer station a comparison of tropospheric ozone loss at the polar regions of both hemispheres will be presented. Special focus will be put on the differences in seasonality, temporal extension and frequency of the phenomenon.

FORMATION OF HALOGENS FROM THE HETEROGENEOUS REACTION OF SEA SALT

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The heterogeneous reactions of the sea salt particles with gases have been recognized as important sources for halogens in the troposphere in the marine boundary region as well as in the Arctic. A newly constructed aerosol chamber is equipped with long-path (150 m) Fourier-transform infrared (FTIR), differential optical absorption spectroscopy (DOAS), and atmospheric pressure ionization mass spectrometry (API-MS). Recently, studies on reactions of sea salt with O_3 have shown the formation of Cl_2 from the photolysis of O_3 in the presence of sea salt particles above their deliquescence point at room temperature, implying a potential source for Cl atoms in the tropospheric marine boundary layer. However, the formation of Br_2 dominated in the reaction of sea water ice with O_3 in the dark. This may be the potential source for Br atoms initiating the ozone depletion in Arctic during polar sunrise. Reaction mechanisms for generation of Cl_2 and Br_2 will be discussed. Studies on sea salt particles with oxides of nitrogen such as NO_2, N_2O_5, HNO_3 and $ClONO_2$ will be also presented.

UV-VISIBLE ABSORPTION CROSS-SECTIONS AND ATMOSPHERIC LIFETIMES OF CH_2Br_2, CH_2I_2 AND CH_2BrI

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The UV-visible absorption spectra of CH_2Br_2, CH_2I_2 and CH_2BrI, which have been found in the troposphere, have been measured over the wavelength range 215-390 nm using a dual beam diode array spectrometer. The spectra consist of broad continuous absorption bands. CH_2Br_2 exhibits its maximum cross-section of $\sigma = 2.71(\pm0.16)\times10^{-18}$ $cm^2molecule^{-1}$ at $\lambda = 219$ nm. The magnitude of the peak cross-sections for the iodine containing molecules are $\sigma = 1.62(\pm0.10)\times10^{-18}$ $cm^2molecule^{-1}$ at $\lambda = 248$ nm and $\sigma = 3.78(\pm0.23)\times10^{-18}$ $cm^2molecule^{-1}$ at $\lambda = 288$ nm for CH_2I_2, and $\sigma = 5.67(\pm0.34)\times10^{-18}$ $cm^2molecule^{-1}$ at $\lambda = 215$ nm and $\sigma = 2.34(\pm0.14)\times10^{-18}$ $cm^2molecule^{-1}$ at $\lambda = 267$ nm for CH_2BrI. The temperature dependence of the absorption cross-sections was investigated over the temperature range 348 K to 250 K. A decline in the cross-sections with decreasing temperature was observed in the tail of the spectra. At the peaks the opposite effect was observed. The photolysis rates of CH_2Br_2, CH_2I_2 and CH_2BrI were calculated as a function of altitude and solar zenith angle using the measured cross-sections. Model calculations show that during sunlit hours CH_2I_2 and CH_2BrI will be photolysed within minutes and hours respectively. The reaction with the OH radical was found to be the dominant loss process for CH_2Br_2.

A NOVEL APPROACH TO DERIVE INTEGRATED HALOGEN ATOM CONCENTRATIONS FROM CHANGES IN VOC PATTERN DURING TROPOSPHERIC OZONE DEPLETIONS

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Tropospheric ozone depletions have been observed in the arctic for more than 15 years. These are caused by significant concentrations of bromine and chlorine atoms. Yet, no direct measurement technique for quantifying the amounts of free halogen atoms in ozone depleted air masses is available. However, the chlorine and bromine concentrations can be estimated from changes in hydrocarbon pattern. This method depends crucially on the estimate of initial hydrocarbon mixing ratios, which have been in the air mass before chlorine and bromine where injected. During spring the arctic troposphere is assumed to be well mixed. Thus, the initial mixing ratios should be similar to the mixing ratios in air masses with typical ozone levels (30-40 ppb). Since ozone depleted air masses are always isolated from the background atmosphere by inversions, it should be examined how reliable those estimates of initial mixing ratios are. Changes in the pattern of selected organic trace gases determined during the ARCTOC 96 experiment at Ny Ålesund, Spitsbergen, have been investigated for chemical processing and mixing. The results confirm the assumption of an initially well-mixed spring arctic troposphere. The integrated halogen atom concentrations derived in this study agree well with earlier estimates.

GOME MEASUREMENTS OF TROPOSPHERIC BRO IN NORTHERN HEMISPHERIC SPRING

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Periods with enhanced tropospheric BrO concentrations have been reported by several groups both for the Arctic and Antarctic spring. These episodes are often correlated with decreasing tropospheric ozone concentrations and therefore an indication of bromine catalysed tropospheric ozone destruction.
In this study, measurements of the satellite instrument GOME have been evaluated for absorptions by tropospheric BrO. These data give for the first time a global view of the phenomenon. Both the geographical extension and the temporal evolution of the tropospheric BrO events will be discussed for the first half of 1997. The global coverage of the GOME instrument also allows a rough estimate of the contribution to the tropospheric bromine loading in the northern hemisphere.

MULTIPHASE PHASE CHEMISTRY OF XNO2 AND HOBR IN RELATION TO TROPOSHERIC HALOGEN ACTIVATION

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Halogen activation has been observed in the marine boundary layer (MBL) both inpolluted and remote locations. The reactions, that are thought to be essential for maintaining large amount of photochemically active species in the gas phase, are :

$$HOBr + Y^- \rightarrow \text{products}$$
$$XNO_2 + Y^- \rightarrow \text{products}$$

where Y^- represents Cl^-, Br^- or I^-. In order to get a throughout understanding of the rapid loss of surface ozone in the MBL, it is therefore necessary to investigated the kinetics of these reactions and to identify the potential products.
We performed such a study using the droplet train and wetted-wall techniques coupled to infrared and mass detection facilities. Current results describing the effect of temperature, aqueous phase composition on the uptake rates will be presented.

OA18

THE UV ABSORPTION CROSS-SECTION AND ATMOSPHERIC PHOTOLYSIS RATE OF HOI

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Gas phase hypohalous acids, HOX (X = Cl, Br, I) act as temporary halogen reservoir species throughout the atmosphere. HOX species are formed in the gas phase reaction of the halogen monoxide (XO) species with HO_2. Subsequent photolysis of HOX to yield OH + X can lead to completion of a catalytic cycle for ozone destruction. A recent modelling study has shown that HOI is the main iodine containing species in the troposphere.
In this work, we have measured the UV-visible absorption cross-sections of HOI, in order to determine its lifetime with respect to solar photolysis in the atmosphere. HOI was prepared in a flash photolysis apparatus using the gas phase reaction of OH radicals with I_2. The UV spectrum of HOI was recorded using a CCD detector and calibrated by measuring consumption of I_2. The absorption cross-section of HOI was used to calculate the solar photolysis rate of HOI in the troposphere.

HETEROGENEOUS REACTIONS OF HALOGEN CONTAINING TRACE GASES ON NACl AND KBr SALT

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Heterogeneous reactions of bromine containing atmospheric trace gases on sea-salt aerosols are assumed to be responsible for the sunrise chemistry leading to significant tropospheric ozone depletion in the Arctic. We studied the heterogeneous reactions of XNO_2, $XONO_2$ and HOX (X = Cl, Br) on NaCl and KBr salt using a Knudsen reactor equipped with mass spectrometry and laser induced fluorescence detection.
Uptake coefficients involving Br-containing compounds are found to be higher than the corresponding Cl-containing reactions. As products we observed Br_2, BrCl and Cl_2 depending on the gas and solid phase. We will present the kinetics and mechanism of these reactions. By using salt samples of well-defined total external surface and applying a pore diffusion model to the obtained uptake rates we consider diffusion of the gas into the bulk of the salt sample and thus determine true uptake coefficients γ_0. Furthermore we will discuss the role of water absorbed on the salt surfaces. In order to expand our data to more realistic surfaces we also present some results using synthetic sea-salt samples.

MODELING THE CHEMISTRY OF OZONE AND HALOGEN COMPOUNDS IN THE MARINE BOUNDARY LAYER

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The box model 'MOCCA' (Model Of Chemistry Considering Aerosols) has been developed to study the tropospheric chemistry in the marine boundary layer (mbl). The chemical mechanism considers gas-phase reactions as well as aqueous-phase reactions in sulfate and sea-salt aerosol particles. Photochemical reactions are switched on during daytime. Their rates vary according to the solar declination. Apart from the standard tropospheric HO_x, CH_4, and NO_x chemistry, the chemical reaction mechanism includes sulfur, chlorine, bromine, and iodine compounds. Model results were published for the polluted mbl (*J. Geophys. Res.* 101D, 9121-9133, 1996) as well as for the remote mbl (*Nature* 382, 327-330, 1996).
Current model development focusses on four aspects: 1) The effect of aerosol acidity on aqueous-phase chemistry; 2) Analysis of the marine iodine chemistry; 3) Explicit calculation of aerosol chemistry as a function of aerosol size; and 4) The effect of cloud processing on aerosol chemistry. Latest results will be presented.

STUDY OF IODINE OXIDES AND IODINE OZONE CHEMISTRY USING FLASH PHOTOLYSIS AND TIME RESOLVED ABSORPTION SPECTROSCOPY

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Based upon observations of IO and OIO absorption spectra reported earlier (Himmelmann et al. 1996) the gas phase reactions of the I-O3 system following the photol yzation of I2 in the presence of O3, O2 and N2 were investigated. The experiment comprised of a flash photolysis set-up and two time resolved absorption spectroscopy systems using a photomultiplier tube PMT and a photodiode array PDA. The measurements were performed at room temperature 293,7 K and at pressures ranging from approximately 10 to 50 mbar. In addition to the absorption spectra of O3, I2, IO and OIO four new absorbers could be observed, one of those having been reported earlier by Sander (Sander 1986). For two of theses absorbers it was possible to record qualitative absorption spectra yet without absolute scaling of the absorption cross section axis=2E Using the monitored temporal behaviour of the main components O3, I2, IO and OIO, estimates for the cross sections sIO and sOIO and for the rate constants of the first reactions following the production of IO were determined. This work was partially funded by the German Space Agency DARA (contract 50EP9207), the Commission of the European Community (contract EV5V-CT93-0338), and the University and the State of Bremen.

EMISSION OF REACTIVE ORGANOCHLORINES AND ORGANOBROMINES FROM COASTAL MACROPHYTES

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A number of macrophytes from the Norfolk coast were incubated in the laboratory and emissions of volatile organohalogens determined. A large number of chlorinated, brominated and iodinated organics were detected. Attention here is focused on the chlorinated compounds and their potential contribution to atmospheric levels. A GIS analysis was used to determine gridded global coastal zone areas. Combining emission rates (including previously published data), with coastal area, average biomass loadings, and latitudinally-weighting primary productivity, yields annual emission rates by latitude. Globally integrated emissions amounted to 4 tonnes Cl per year from $CHCl_3$, 0.5 tonnes Cl per year CH_3Cl, and just 0.01 tonnes per year CH_2Cl_2. For $CHCl_3$ and CH_3Cl these concentrations are comparable with industrial emissions, but fall far short of total global emissions. Local levels in coastal regions may, however, be significant. The impact of organobromine emissions are also assessed.

GOME OBSERVATION OF ENHANCED TROPOSPHERIC BRO CONCENTRATION IN THE POLAR SPRING

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Since about a decade now the phenomenon of complete ozone depletion in the Arctic boundary layer is known, it was recently also found in Antarctica. While during the last years it was shown that these O_3 loss events are caused by BrO-catalysed O_3 destruction the origin of the high BrO concentrations remained unclear. Here we present the first satellite measurements of enhanced tropospheric BrO columns in the Arctic and Antarctic spring. The observed tropospheric BrO vertical column densities are up to $5 \cdot 10^{13}$ molec/cm^2 on top of a stratospheric column of about $2.5 \cdot 10^{13}$ molec/cm^2. Thus the derived tropospheric mixing ratios of about 35 ppt (if a layer thickness of 1 km is assumed) are in good agreement with ground based observations. From satellite observations it is possible to study directly the spatial and temporal evolution of airmasses with enhanced tropospheric BrO concentrations. We present several case studies of enhanced tropospheric BrO. For all of these observations the BrO concentrations stay elevated for about 1 - 3 days thus supporting the theory involving autocatalytic Br release, probably from sea salt deposits on the sea ice.

CHEMISTRY OF HALOGEN OXIDES IN THE TROPOSPHERE: COMPARISON OF MODEL CALCULATIONS WITH RECENT FIELD DATA

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The discovery of sudden boundary layer ozone depletion events in the arctic spring and the simultaneously elevated bromine concentrations raised the interest in the sources and the chemistry of halogens in the troposphere. While the identification of BrO by differential optical absorption spectroscopy (DOAS) confirmed the catalytic processes responsible for the destruction of ozone by BrO and possibly also ClO and IO, the circumstances leading to the formation of the halogen oxides in these environments remain unclear. Recent DOAS measurements have found elevated BrO and IO levels at the Dead Sea, Israel and at Mace Head, Ireland respectively, showing that tropospheric halogen liberation also occurs at mid latitudes.
Model calculations describing the tropospheric halogen chemistry in the arctic and at mid latitudes are presented. The calculations aim to improve the understanding of the multiphase chemical processes leading to the formation of BrO and IO in the different environments. The influence of the measured halogen oxide concentrations on ozone is also discussed.

DOAS UV/VISIBLE MEASUREMENTS AT NY-ÅLESUND 1995-1997: RETRIEVAL OF TROPOSPHERIC CONSTITUENTS

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Measurements and modeling studies strongly suggest that depletion of ozone in the Arctic boundary layer is due to catalytic destruction by halogenous cycles. In this study three years of observations of BrO, OClO, and IO by means of zenith sky differential optical absorption spectroscopy are presented. These measurements are complemented by comparison with observations by the satellite instrument GOME onboard ERS-2.
High tropospheric amounts of BrO could be observed from the middle of March to the beginning of June every year. They are always correlated with low amounts of boundary-layer ozone. From the data BrO concentrations of up to 40 ppt in the lower troposphere are derived. Further, in a few cases significant levels of OClO and possibly IO could be observed. Upper limits of 15 ppt (OClO) and 10 ppt (IO) in the boundary-layer could be estimated. This is the first hint, that IO is present in the atmosphere in considerable amounts.

THE CHEMISTRY OF IODINE IN THE MARINE BOUNDARY LAYER

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Measurement of organic iodine compounds indicate that species, such as CH_2I_2 and C_3H_7I, might have a much larger source strength than CH_3I, the only organic iodine compound which is commonly accounted for in the global iodine budget. Organic iodine compounds are formed in biogenic processes of certain macroalgae and phytoplankton. Because of the supersaturation of the surface water these compounds evaporate and can be detected in the marine air.

We have incorporated such compounds, together with the latest photolysis rate data, into our photochemical box model. Partitioning of iodine between the gaseous and particulate phase is calculated and the impact on the ozone budget in the remote marine boundary layer is investigated.

OBSERVATIONS AND MODELLING STUDIES OF REACTIVE IODINE SPECIES IN THE MARINE BOUNDARY LAYER

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Following field studies of the Iodine Oxide Radical (IO) during three measurement campaigns in the Northern Hemisphere, extensive modelling studies were made to investigate the sources, sinks and potential impact of reactive iodine in the marine boundary layer. It has been hypothesised that IO may be involved in autocatalytic cycles which have a significant effect on the depletion of tropospheric ozone and are responsible for modulation of the NO_2/NO and HO_2/OH ratios. Following measurements of the organic iodine precursors and of aerosol size distributions, it has been possible to model the sources and sinks of inorganic iodine and hence to infer the heterogeneous chemical behaviour of inorganic iodine species required to produce the observed levels of IO. The importance of reactive iodine species in the destruction of tropospheric ozone has also been assessed. DOAS measurements of IO during the three measurement campaigns will be presented along with the modelling results.

BROMINE RADICALS AND PHOTOLYSABLE HALOGEN COMPOUNDS DURING POLAR SUNRISE AT ALERT, CANADA

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Two instruments were used to measure halogen species at Alert NWT Canada. during the spring of 1997. A modified radical amplifier measured the bromine radical (Br, BrO) concentrations and an updated photolysable halogen detector (PHD) measured the compounds capable of producing halogen radicals. This detector can now distinguish between species on the basis of their photolytic lifetime. in this case it was configured for HOX and X_2. Two ozone depletion events were studied. Higher bromine radical and photolysable halogen concentrations were observed as the atmosphere returned from an ozone depletion event to normal conditions. The dominant photolysable species was identified as HOX. particularly for X=Br.

OA19 Free-radicals in the troposphere (joint with ST)

Convener: Dorn, H.-P.
Co-Convener: Volz-Thomas, A.

STUDIES OF THE NITRATE RADICAL IN THE TROPOSPHERE

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The technique of differential optical absorption spectroscopy (DOAS) has been used to study the nitrate radical (NO_3) in several major field campaigns in the marine boundary layer (MBL). Concentrations as high as 10 ppt have been observed in clean marine air. An extensive set of ancillary measurements acquired during these campaigns allows nearly complete closure to be obtained on the loss processes of NO_3 in the MBL. A second zenith pointing DOAS instrument has also been deployed at the same sites in order to retrieve the column abundance of NO_3 throughout the troposphere during sunrise. By combining data from both instruments the column abundance of NO_3 in the free troposphere has been estimated and found to be very variable, ranging from 2×10^{13} to 5×10^{14} molecule cm^{-2}. Under favourable circumstances, the vertical profile of NO_3 up to the lower stratosphere can also be retrieved by this technique.

SIMULTANOUS DOAS-MEASUREMENTS OF HONO AND ITS PRECURSORS IN A TRAFFIC TUNNEL

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Nitrous acid (HONO) plays an important role in photochemical air pollution through its photodissociation by solar UV radiation into hydroxyl radicals (OH + NO), thus promoting atmospherical photochemistry. Therefore the production of O_3 and other secondary pollutants should be enhanced by the formation of HONO. In the early morning photolysis of HONO leads to OH production rates up to some 10^7 OH radicals cm^{-3} s^{-1}. Simultanous measurements of HONO and NO_2 using a multi reflection DOAS system and NO by in-situ analyzer were performed in a heavily used traffic tunnel. Additionally the ambient concentrations of HONO, NO_2 and NO were measured outside the tunnel. The HONO concentration in relation to the traffic density can be used to estimate the amount of primary HONO emission. Furthermore the heterogenous formation of HONO from NO_x on the walls of the tunnel can be investigated at times of low traffic densities. The emission of HONO from the tunnel into the urban atmosphere is estimated and discussed in the light of its potential as a photochemical OH source.

ROLE OF PEROXY RADICALS IN THE FORMATION OF TROPOSPHERIC OZONE IN BREMEN

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The role of peroxy radicals (HO_2 + Σ (RO_2)) in the photochemical cycles of the troposphere is recognized to be of major significance for the composition of the troposphere, the latter impacting on local pollution events and potentialy on the climate. HO_2 and RO_2 have singled out as being of special importance in the formation of tropospheric O_3 . The chemical amplification (CA) is the technique which has been used to measure total peroxy radicals (RO_x = OH+ HO_2 + RO+ RO_2).The CA is based on the conversion of peroxy radicals into NO_2 by addition of NO and CO, and NO_2 ulterior measurement via its chemiluminiscent reaction with luminol. The detection limit is estimated to be 3-5 ppt RO_x depending of atmospheric conditions. During episodes of elevated boundary layer O_3 concentrations, observed in Bremen between 1995 and 1997, measurements of RO_x, coupled with NO, NO_2, CO, O_3, UV-A, UV-B, meteorological parameters and recently PAN (peroxyacetyl nitrate) were performed. These data have been analysed using empirical approaches and a simple atmospheric model. The results and their significance for our understanding of tropospheric chemistry in the boundary layer will be discussed .

TESTS AND EVALUATION OF AN ION ASSISTED MASS SPECTROMETRIC TECHNIQUE FOR LONG-TERM MONITORING OF ATMOSPHERIC OH-RADICALS

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Atmospheric OH-radicals are measured with an improved ion assisted mass spectrometric technique based on OH titration with SO_2 and conversion to HSO_4^- ions at atmospheric pressure. The present system was developed for both mobile and stationary measurements of OH as well as gaseous sulfuric and methane sulfonic acids with detection limits in the low 10^5 cm^{-3} range. In future applications the system will be mainly used for long-term monitoring of OH and sulfuric acid at the Hohenpeissenberg observatory in conjunction with a large set of atmospheric trace gas, aerosol, and meteorological measurements. Details of the system are presented, results obtained from calibration checks based on photolysis of ambient H_2O are discussed, and various tests for possible interferents (e.g., reactant impurities), ambient air pollution (NO_x), and wind turbulence effects are evaluated for possible error contributions. First measurements in ambient air indicate a good correlation between daytime OH signals and global radiation flux. Further tests, parallel ozone photolysis measurements, and a field intercomparison with the Juelich DOAS and LIF techniques are planned for the near future.

MODELLING RADICAL CHEMISTRY IN THE MARINE BOUNDARY LAYER

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The hydroxyl (OH) radical has long been recognised as the most important oxidising species in the earth's troposphere, and is largely responsible for the removal of many man-made and natural trace gases. In recent years, there have been several field studies where the concentration of OH has been determined in the atmosphere, and modelling studies have complemented these measurements. In general, the models have tended to over estimate the OH concentration. In this paper we discuss two campaigns that have been recently held at Mace Head on the west coast of Ireland, as part of the ACSOE EASE96 and EASE97 campaigns. The Mace Head site is typically subject to very clean air when the flow is from the west. However, dirty air masses are also experienced that have often passed over mainland Europe or the UK before reaching Mace Head. These varying conditions give us an excellent chance to thoroughly test models of atmospheric chemistry. During these campaigns, the concentration of OH and HO_2 were determined by Fluorescence Assay by Gas Expansion (FAGE) and the concentration of the sum of peroxy radicals by chemical amplification. A box model has been constructed to predict the concentrations of these radicals, and these predictions are compared to those measured in the atmosphere. We also present a detailed analysis of the most important reactions in the remote marine boundary layer.

INFERRING OH CONCENTRATIONS FROM DIURNAL VARIATIONS OF NON-METHANE HYDROCARBONS

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Daily mean hydroxyl radical (OH) concentrations at a rural site in Switzerland are inferred from diurnal variations of ratios of non-methane hydrocarbons (NMHCs). Suitable combinations of NMHCs are selected by examining the sensitivity of the derived OH concentrations on the difference between the respective NMHC reactivities toward OH. Calculated OH-concentrations average in summer to 3 x 10^6 molec cm^{-3}. This figure is consistent with model results and direct measurements in moderately polluted air in Europe.
Derived concentrations show a significant correlation with the daily maximum global radiation and the daily maximum ozone concentration. Both quantities are known to play an important role in the formation of the OH-radical. Calculated regression curves of OH against these parameters for the summer of 1996 are tested against those computed for the summer of 1997. Changes in the regression coefficients are discussed with respect to variations in meteorological conditions and precursor levels.

PEROXY RADICAL INITIATIVE FOR MEASUREMENTS IN THE ENVIRONMENT (PRIME): A NEW EU PROJECT

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PRIME aims to develop improved instrumentation for measurements of HO_2 and RO_2 radicals in the troposphere using the Chemical Amplification (CA) and Fluorescence Assay by Gas Expansion (FAGE) techniques. The improvements will address the specificity, sensitivity, accuracy and precision of the measurements. Novel CA and FAGE inlet systems will be constructed. Better characterised and new calibration sources for OH, HO_2, CH_3O_2 and $CH_3C(O)O_2$ radicals will be developed. Numerical models incorporating gas-phase and heterogeneous chemical reactions and physical fluid dynamical processes will be applied to aid the design and characterisation of the inlet systems and calibration sources. The improved instrumentation will be evaluated in a field measurement study in the summer of 1999 at the Silwood Park Atmospheric Research Station, near London. The field study is designed to compare ambient measurements of peroxy radicals using CA and FAGE under challenging sub-urban conditions. A deeper understanding of the sources and sinks of peroxy radicals will also be gained through the application and validation of the MCM PTM model of tropospheric photochemistry and transport.

CHEMICAL PROCESSES AFFECTING THE GLOBAL DISTRIBUTION OF OH IN A TROPOSPHERIC LAGRANGIAN CHEMISTRY MODEL.

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A three-dimensional Lagrangian tropospheric chemistry model was used to simulate the global distribution of the OH radical. This model also provided a budget of all the OH production and destruction terms. To verify the free radical distribution the model simulated the lifetime of methylchloroform and the distribution of 14-CO which were then compared against measurements. As a sensitivity test the reaction coefficients for each of the major processes affecting OH were varied in turn by their published tolerances. This test showed that the uncertainties in the basic chemical kinetic data leads to significant uncertainties in the global OH distribution
Our chemistry scheme contains 70 species including the non-methane hydrocarbons: ethane, ethene, propane, propene, butane, toluene, o-xylene and isoprene. The oxidation of these produces peroxy radicals which can lead to ozone formation through NO to NO2 conversion. We have investigated the importance of the loss route for these radicals via the reaction: peroxy+HO2=hydroperoxide+O2 where the hydroperoxides can be removed through dry or wet deposition. We show that the neglect of hydroperoxide formation leads to the significant overestimation of free radical concentrations.

MEASUREMENT OF HO_X IN THE MARINE BOUNDARY LAYER

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An instrument to detect atmospheric concentrations of the hydroxyl (OH) and hydroperoxyl (HO_2) radicals has been developed using the FAGE (fluorescence assay by gas expansion) technique. The instrument monitors the OH radical via on-resonance laser-induced fluoresence (LIF) spectroscopy of the $A^2\Sigma$ ($v' = 0$) - $X^2\Pi_i$ ($v'' = 0$) transition at 308nm. Ambient air is expanded through a 1mm nozzle to low pressure where it is irradiated by the laser pulse at a repetition rate of 7kHz, with the resultant flourescence being detected by gated photon counting. HO_2 is monitored by chemical conversion to OH by the addition of NO, with subsequent detection using LIF. Detection limits of 5 x 10^5 and 2.5 x 10^6 molecule cm^{-3} (signal to noise ratio of 1, integration time of 150s) for OH and HO_2 respectively, were determined by laboratory and field calibrations. The instrument was deployed in the marine boudary layer at Mace Head, Eire, during April and May of 1997 as part of the ACSOE field campaign. Selected results will be presented at this conference.

MEASUREMENTS OF NITRATE RADICALS AND ESTIMATION OF PARTICLE SURFACE AREA AT CAPE ARKONA (RÜGEN ISLAND)

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Long-path Differential Optical Absorption Spectrometer (DOAS) measurements of nitrate radicals were carried out in the marine boundary layer at the rural site Arkona. Observations between April 1993 and September 1995 cover a period of nearly 30 months. The mean NO_3 concentration refers to the night time averages for summer and autumn fluctuate between 7 and 10 ppt. Particulate extinction measurements in the wavelength region from 320 nm to 680 nm have been performed by means of a DOAS system. This allows a rough estimate of the particle number concentrations from about 100 cm^{-3} to several 1000 cm^{-3}, and of the mean surface area concentration from about 350 $\mu m^2/cm^{-3}$ during summer 1995. The calculated NO_3 and N_2O_5 lifetime versus the particle surface area concentration derived from DOAS measurements for summer 1995, confirm that the maximum lifetimes increase with smaller aerosol surface concentrations. On the one side, the upper limits for the NO_3 and N_2O_5 lifetimes give evidence for the limiting case of radical loss exclusively by reactions on the aerosol surface. On the other hand, it is clear that at most times other loss processes are dominant yielding considerably smaller lifetimes. This can be due to homogeneous gas phase reactions. An investigation of NO_3 night time variations and an assignment of the lifetime determining processes from additional meteorological and chemical information will be presented.

VOLATILE ORGANIC COMPOUNDS AND PEROXY RADICALS CONCENTATIONS FOR URBAN AND RURAL REGIONS OF RUSSIA

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The results of measurement of volatile organic compounds (VOC) concentrations in different urban and rural regions of the European part of Russia and Siberia got at the moving laboratory along the main line «Moscow-Vladivostok» are presented in the report. The content of alkanes, alkenes, aldehydes and agents of the other groups of hydrocarbons and their reactants (total 45-65 agents) in air samples picked in the sorbtion tubes was determined. VOC content and their character interrelation for rural regions give possibility to separate some areas: European, West Siberia, South Siberia, and East Siberia. VOC concentration in urban air depend on local pollution sources. On the base of trajectory analysis method the attempts to allocate the VOC sources were made.
At the same time in these regions were made the measurements of O_3, NO_x and UV radiation fluxes. On the base of these data concentration of peroxy radicals was estimated. For the some regions (Moscow and others) the analysis of minor constitutes concentrations behaviour in dependence on the industrial stress was made. Comparison of VOC and peroxy radicals distribution features shows the relation between them and characterizes oxidative atmosphere ability under different conditions. Using peroxy radicals as the trace compound of atmosphere pollution is discussed.

MEASUREMENTS OF PEROXY RADICAL CONCENTRATIONS IN A PERI-URBAN ATMOSPHERE USING THE CHEMICAL AMPLIFIER METHOD

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Peroxyl radical concentrations have been measured at a site located 10 km downwind from Orléans during two weeks in July 1997. The measurements were performed using the chemical amplifier instrument developed at CNRS. The amplification was obtained from the RO_2/NO/CO system, and the NO_2 produced was measured by chemiluminescence of luminol. The daily variations of RO_2 concentrations were measured together with those of ozone and NO_x (NO, NO_2). The NO_x concentrations ranged from a few ppbv to 15 ppbv and ozone maxima of 70 - 80 ppbv were observed almost every day. The daily profiles of RO_2 concentrations showed maxima from a few tens to 100 pptv during daytime with non-zero concentrations sometimes observed during nighttime. The maxima of RO_2 concentrations always appeared before those of ozone. These observations will be discussed referring to the current knowledge of the photochemical pollution.

TROPOSPHERIC OH BOX-MODELLING AND ANALYTICAL STUDIES: COMPARISON WITH OBSERVATIONS FROM THE WAOSE'95

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Data of the most tropospheric relevant trace gases, collected in June 1995 during the Weybourne Atmospheric Observatory Summer Experiment (WAOSE'95), were used to box-model the concentration of the free radicals playing a prominent role in the oxidising capacity of the atmosphere. The observatory (TOR Station No. 7) can be characterised by a clean atmospheric environment that occasionally is influenced by anthropogenic emissions of the industrial region in the central UK. The box-model was constrained to observations and is based on the gas phase reactions of the *regional acid deposition model (RADM2)*. The calculations were compared with in-situ measurements of the OH radical concentration taken by the Multipass Optical Absorption Spectroscopy (MOAS) system. Its temporal and spatial resolution of 1 minute and 6 m, respectively, together with the extended input into the model provides a well suited opportunity for testing the actual theory of atmospheric chemistry. Agreement of theory and experiment for most part of the campaign is given, but deviations exist.

LABORATORY STUDIES ON THE SELECTIVE MEASUREMENT OF ORGANIC PEROXY RADICALS AND HO_2 BY CHEMICAL CONVERSION/ ION MOLECULE REACTION MASS SPECTROMETRY

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Results of recent field and laboratory studies which were conducted with a novel method for groundbased and aircraft-based measurements of peroxy radicals will be presented. The main characteristics of this method developed at our laboratory are chemical conversion and amplification of peroxy radicals to sulfuric acid and detection of H_2SO_4 by ion molecule reaction mass spectrometry (IMRMS). One part of the studies aimed at the calibration of the instrument and diagnostic investigations on interference and loss processes and conversion efficiency. Further laboratory works focused on the discrimination between organic peroxy radicals and HO_2 to develop an HO_2-only measuring mode of operation and on the conversion efficiency of organic peroxy radicals to HO_2.

A QUALITY CONTROL / QUALITY ASSESSMENT METHOD FOR ATMOSPHERIC NON-METHANE HYDROCARBON (NMHC) MEASUREMENTS

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Reactive hydrocarbons plays a crucial role in the chemistry of free radicals in the atmosphere. The processes cannot be studied without reliable, representative hydrocarbon concentration data. Having an existing data set of atmospheric NMHC measurements the types of compositions can be defined by cluster analysis. The types are site specific and may depend on the season, on the air mass sampled, its trajectory and chemical age, as well as on other factors. Analysing all the conditions of the measurements those type(s) can be selected which represent(s) the background conditions at the given site. Samples in the other clusters may be non-representative for the background conditions due to the special atmospheric conditions, sampling or analytical errors. Any new air sample can be accepted as representative for the background conditions if its composition falls into one of the selected clusters. The presentation discusses the NMHC measurements from K-puszta, Hungary, for the illustration of the method. It also presents the treatment of the partially analysed samples.

OA19

ON THE DEPENDENCE OF THE OH RADICAL CONCENTRATION ON ITS PRECURSORS: RESULTS OF THE POPCORN FIELD CAMPAIGN

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The extensive OH data set recorded during the POPCORN campaign at a rural site in north-eastern Germany in August 1994 was investigated to reveal the dependence of the concentration of OH radicals on its precursors. RADM-2 model calculations and an empirical analysis of the measurement data show that for typical POPCORN conditions the OH concentration was rather insensitive towards variations in the concentrations of most trace compounds. In particular variations in ozone and formaldehyde concentrations had only little influence on OH. The dependence of OH on NO_x could clearly be extracted from the data, showing that OH concentration peaks at 1.5 ppb NO_x and declines towards higher and lower NO_x concentration. Nevertheless, on average for this data set. variation in the NOx concentrations accounts for only 6% of the total OH variability, while variation of photolyses frequencies accounts for 71%. The combination of empirical analyses and model calculation was found to be a skillful method to verify functional connections of concentrations of atmospheric chemical constituents as predicted by the model calculations

PRODUCTION AND DESTRUCTION RATE OF OH AT AN ISLAND AND A SUBURBAN SITE IN GREECE DURING THE 1996 PAUR CAMPAIGN

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During the 1.-15. June 1996 PAUR campaign, concurrent ground measurements of O3, J(O[1D]), humidity, temperature and C4-C12 hydrocarbons have been performed at an island and a suburban site in Greece. The measurements allowed for the calculation of OH production rates, POH, as well as relative destruction rates for the OH reaction with the measured hydrocarbons. Due to the relatively high ozone and irradiance values, daily peak production rates of OH were around 8X106 molecules cm-3 s-1. During most of the days, OH production rates were at the island site higher than the ones at the suburban site, on one case by up to 100%. On at least two days, though, the opposite was true, with OH production rates being at the suburban site around 25% higher than at the island site. A two-days case study is presented, where the observed production rates are discussed in relation with concurrent BREWER measurements of total ozone and LIDAR measurements of aerosol vertical distribution.

OH RADICALS IN THE ATMOSPHERE

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OH is the main oxidizing agent in the troposphere. It reacts with most trace gases, often as the first and rate limiting step in the oxidation mechanism. Thus OH controls the atmospheric lifetime and therefore the concentration of many anthropogenic pollutants and natural trace gases. For about two decades our knowledge about the role of atmospheric OH mainly came from laboratory investigations, modelling studies, or field experiments which yielded indirect evidence of tropospheric OH. Direct observational data on atmospheric OH were scarce due to the technical difficulty of measuring the extremely small concentration of ambient OH. In the last few years the situation has greatly changed since a number of different and promising OH measurement instruments have become operative. The new techniques have yielded exciting observations of OH in a number of different environments on the continent. in coastal areas, on the free ocean, and the free troposphere. This presentation aims to give an overview of this rapid development which has opened new possibilities to study the photochemistry of the atmosphere.

AIRBORNE MEASUREMENTS OF THE ABSOLUTE SOLAR ACTINIC UV FLUX AND THE $O_3 \rightarrow O(^1D)$ PHOTOLYSIS FREQUENCY IN THE TROPOSPHERE BETWEEN 0-12 KM ALTITUDE.

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Spectra of the absolute solar UV actinic flux $F_\lambda(\lambda)$ were measured in the troposphere on-board the DLR Falcon research aircraft over the Aegean Sea in June 1996. The measurements were performed with a dual channel scanning spectroradiometer, equipped with two optical input systems pointing to the zenith and the nadir, respectively. The spatial sensitivity of each individual optical input system was adjusted to be nearly uniform over one hemisphere (2π sr). Thus, the two measurement channels detected the downwelling and upwelling component of the solar actinic flux $F_\lambda(\lambda)$, respectively.
In this work, we present measured vertical profiles of the actinic flux from 290nm - 420nm between ground level and the tropopause. Vertical profiles of the integrated UV-A and UV-B actinic radiation and the $O_3 \rightarrow O(^1D)$ photolysis frequency $J(O^1D)$ calculated from the measured spectra of $F_\lambda(\lambda)$ are shown. The shape of the vertical profile of $J(O^1D)$ is discussed with respect to variations of the actinic flux with altitude and the temperature dependence of the quantum yield $\phi(O^1D)$ from the $O_3 \rightarrow O(^1D)$ photolysis.

INFLUENCE OF THE UNCERTAINTY OF GAS PHASE RATE CONSTANTS ON THE MODELED TROPOSPERHIC OH CONCENTRATIONS

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The rate constants of some important reactions used for atmospheric chemical models are known only with considerable uncertainties of about 10 - 50 %. For example, the rate constant for the reaction of OH with NO_2, which is a very important sink of OH in the troposphere, might be overpredicted by 10 - 30 % at room temperature. Also a revised rate constant for the formation of OH in the reaction of HO_2 with NO has been reported.
Numerical simulations of the OH concentration using experimental data of the POPCORN campaign are presented. The calculations with a simple box model are based on the chemical mechanism RADM2 from the Regional Acid Deposition Model. Some important rate constants are varied and the influence on the calculated OH concentration is presented.

THE EFFECT OF HUMIDITY ON WALL LOSS AND CHAIN LENGTHS IN RADICAL AMPLIFIERS.

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Radical amplifiers involve ambient radicals in a chain reaction with added NO and CO. The length of this chain, the amplification, is determined by the relative rates of the propagation and termination reactions. In most instruments the major chain termination reaction is the loss of peroxy radicals to the walls of the reactor. Since ambient measurements are made under more humid conditions than calibrations and the ambient humidity can change markedly during a day, laboratory studies to investigate the effect of humidity on both the rate of radical loss to the reactor walls, and its impact on the chain length of the detector have been undertaken. The first-order rate coefficient for radical loss to the reactor walls is found to increase with increasing humidity. The chain length of a typical radical detector used in field studies is found to decrease with increasing humidity. A model has been used to reconcile the observed chain lengths with the varying termination rates. The impact of these results on field measurements is discussed.

ISOPRENE AND RADICALS: STIMULANTS FOR THE EXPORT OF CONTINENTAL OZONE ?

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Biogenic hydrocarbons have long been recognised as a potentially important source of peroxy radicals in the atmosphere owing to the nature of their rapid reactions with the primary atmospheric oxidants. Peroxy radicals produced in oxidative processes in the atmosphere can be responsible for significant daytime *in-situ* production of ozone *via* their *catalytic* oxidation of NO to NO_2. Ozone production is a non-linear process and dependant on a number of factors including the availability of NO_x, VOC and HO_x. There seems to be two distinct views as to the role of the biogenic hydrocarbon isoprene in the production of ozone. The first is that if HO_x production is predominately controlled by ozone photolysis then isoprene will have little effect. The second is that isoprene even at the level of a few 10's of pptv may have a significant effect on ozone production. Data from ACSOE-OXICOA EASE96 campaign at Mace Head in Ireland is used to illustrate that during a period dominated by semi-polluted air of UK and European origin, that the biogenic molecule isoprene can play an important role in the production of peroxy radicals and subsequently ozone. Using both measurements and models it has been demonstrated that isoprene can undertake both a direct role in the production of HO_x and an indirect role in the control of NO_x. The sum of these effects has wide implications for the export of regional pollution from urban areas to the background atmosphere.

THE IMPORTANCE OF NITRATE RADICALS FOR ATMOSPHERIC CHEMISTRY.

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Nitrate Radicals (NO_3) react with many organic compounds (VOC) and thus initiate their degradation. In addition they lead (via N_2O_5 formation) to the conversion of NO_X to HNO_3, thus promoting the removal of NO_X from the atmosphere. The much smaller reactivity of NO_3 towards VOC (by several orders of magnitude) compared to OH radicals can be offset by the much higher abundance of NO_3 in many areas. For instance NO_3 can be an important sink of DMS in the marine environment, while at the same time changing the NO_X - NO_Y ratio there.
An interesting feature is the nearly exclusive formation of NO_3 by reaction of NO_2 + O_3, which - in contrast to most OH source mechanisms - proceeds without sunlight. Thus NO_3 - reactions lead to nighttime RO_2- (and even OH) formation.
The contribution of NO_3, in particular during times of low insolation, to the oxidation capacity of the atmosphere and its role in NO_X-removal is discussed in the light of recent findings on the average NO_3 concentration and its vertical distribution in the atmosphere.

AIRCRAFT-BORNE MEASUREMENTS OF PEROXY RADICALS, RELATED TRACE GASES, AND UV RADIATION

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We have carried out aircraft-borne measurements of peroxy radicals, related trace gases, and UV radiation at altitudes between 3.7 and 7.8 km. Peroxy radicals were measured by chemical conversion to gaseous sulfuric acid and detection of sulfuric acid by ion molecule reaction mass spectrometry. The peroxy radical instrument was calibrated and thoroughly characterized by in-flight and laboratory diagnostic measurements. Results of diagnostic measurements as well as results from the measurement flights will be presented and discussed.

INVESTIGATION OF THE EFFECTIVE ABSORPTION CROSS-SECTIONS OF WATER VAPOUR AND OXYGEN FOR THE VUV EMISSION OF LOW PRESSURE MERCURY LAMPS AT 185 NM

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The photolysis of water vapor in air by the 185 nm radiation of a low pressure mercury lamp is a widespread HO_x source for calibration of field instruments that measure atmospheric OH and HO_2 concentrations. The determination of the generated radical concentration depends critically on the correct value of the H_2O absorption cross-section at 185 nm. If the photon flux is monitored by O_2/O_3 chemical actinometry, the effective O_2 absorption cross-section (σO_2) must also be known accurately. Following a recent experimental study of Lanzendorf et al. we have reinvestigated the absorption of the 185 nm Hg-lamp radiation by O_2 and H_2O for the conditions used in the HO_x calibration of our LIF-instrument in Jülich. We present typical VUV emission spectra of several Hg lamps measured with a VUV spectrometer at high spectral resolution of 0.01 nm and 0.05 nm. These measurements clearly demonstrate that the 185 nm line has an individual spectral shape for each lamp and exhibits a long tail towards wavelength up to 200 nm. The different overlap with the O_2 Schumann-Runge absorption lines results in different σO_2 values for each lamp as well as in different dependencies of σO_2 on the O_2 column. We also present new measurements of the effective absorption cross-sections of H_2O at 185 nm which will be compared with other recent literature values.

ON THE STATUS OF PEROXY RADICAL MEASUREMENTS: RESULTS FROM THE PEROXY RADICAL INTERCOMPARISON EXERCISES I+II

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Peroxy radicals (HO_2 and its organic homologues, RO_2) are the key intermediates in the oxidative decomposition of CO and hydrocarbons and in the formation of photo-oxidants such as ozone, PAN and other organic nitrates, and peroxides. Measurements of peroxy radicals thus provide important insight into the fast photochemical cycles in the atmosphere. Measurements of peroxy radicals have been reported using Matrix Isolation/ESR-spectroscopy (MIESR), Laser Induced Fluorescence (LIF), and Chemical Amplification (CA).
This contribution will discuss the findings from two international exercises (PRICE and PRICE II) which were concerned with the comparison of the different techniques for peroxy radical measurements. Emphasis of PRICE was the comparison of MIESR and several CAs in the atmosphere, whereas PRICE II was mainly concerned with obtaining a better understanding of the particular problems associated with the chemical amplifier, e.g. detection efficiency for RO_2 versus HO_2, and the various radical sources that are used for calibration of the CA.

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THE MEASUREMENT OF TROPOSPHERIC HO_2 RADICAL CONCENTRATIONS BY LASER-INDUCED FLUORESCENCE AT LOW PRESSURE

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Photochemical oxidation of most natural and anthropogenically produced atmospheric trace gases is initiated by reactions with hydroxyl radicals (OH) and leads to the formation of hydroperoxyl radicals (HO_2). While in the last years a number of high quality OH data sets have been obtained by different measurement techniques, reliable HO_2 measurements are still sparse. In order to measure both radicals in parallel with a high time resolution we have extended the capabilities of our current OH laser-induced fluorescence instrument by adding a second measurement channel for the detection of HO_2 radicals. While this instrument directly detects OH radicals, HO_2 radicals have first to be converted into OH by reaction with NO. In order to quantify the HO_2 measurements not only a thorough understanding of the chemical conversion step inside the fluorescence chamber and its influence on the detection sensitivity is needed but also a well characterized HO_2 radical source has to be available for the calibration of the instrument. In our presentation we will describe the experimental setup of the HO_2 channel and will discuss several experiments which were performed in order to arrive at a comprehensive understanding of the different mechanisms underlying the successful measurement of HO_2 radical concentrations by LIF spectroscopy.

OA20 Radiogenic isotopes as tracers of source-areas for aerosols, suspended matter and sediments (joint with ST)

Convener: Grousset, F.E.
Co-Convener: Sirocko, F.

TRACKING PARTICLES AND PARTICULATE PROCESSES WITH RADIOGENIC ISOTOPE TRACERS

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The processes by which minerals become detached from parent rocks and each other, become ground down, partly dissolved and transformed into other minerals, are transported by moving water, wind and ice to intermediate and final places of deposition on the continents and in the oceans -- these processes reflect an enormous range of physical and chemical conditions of the Earth's surface and of its fluids of air and water. To decipher the record of these processes and conditions from sediments generally requires that they be traceable back to the primary rocks from which they were derived. Tracer characteristics for this determination of provenance must be, at least in combination, diagnostic of the source area and must be reasonably conservative throughout the intervening processes to their ultimate deposition. Natural isotope compositions of several radioisotope systems provide excellent tracer characteristics because they vary with the lithologies and geologic ages of parent rocks, which themselves vary on spatial scales comparable to those of the physical and chemical processes elucidated. The geochemistries of the several radioisotope systems react differently to these weathering and transport processes. We will review the several decades of use of these isotope systems (Rb-Sr, Sm-Nd, U-Pb) by the authors and others to study marine, lacustrine and soil sediments and modern aerosols as well as the record of paleoaerosols in polar ice cores and snow.

GCM MODELING OF ATMOSPHERIC DUST TRANSPORTATION WITH CONSTRAINS ON PALEO SOURCES

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From measurements of radiogenic isotopes it has been possible to put certain limits on the location of the possible sources of mineral dust transportated to the polar ice caps during the Last Glacial Maximum. We here present the results of simulating the atmospheric dust cycle in an atmospheric general circulation model. The results of the model were compared to results from measurements of radiogenic isotopes in dust from the ice cores and potential source areas. Model results for the Last Glacial Maximum, in consistance with measurements, show a strong transportation of dust from Patagonia to the Antarctic ice sheet. For the Greenland ice sheet the situation is somewhat more complicated due to the proximity of several potential source areas. However the measurements provide constrains on the sources of eolian dust, which are most important for the simulation of dust transportation in a paleo-environment, where information on e.g. vegetation and soil texture are rather scarce.

Sm/Nd ISOTOPES IN CONTINENTAL AEROSOLS: RESULTS FROM A STUDY OF EPIPHYTIC LICHENS

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Epiphytic lichens hanging in trees provide a natural means of filtering atmospheric particles over large geographic areas. Concentrations of non-soluble elements in these particles are found in ratios comparable to those of continental crustal sediments. We report Sm/Nd isotopic results from lichens collected in Europe and N. America, where geological terrains range in age from Archean to Cenozoic. This large age variation permits the aerosol sources to be easily traced by their Nd isotopic compositions. Additionally it allows us to investigate whether trace element ratios of aerosols have varied with crustal residence age, estimated from the Nd isotopic composition. Our preliminary data display a range in $^{147}Sm/^{144}Nd$ that varies from 0.096 to 0.121 and correlates with a range in Nd model age from 2.7 Ga to 1.5 Ga. These ages are consistent with the geological ages of the terrains in which the lichens were collected. The observed correlation agrees with that found among river sediments in previous studies (Goldstein et al., 1984; Goldstein and Jacobson, 1988). We find no correlation between major element composition, as expressed by Ti/Al ratio, and Nd model age. This suggests that the observed trend does not result from mixing between young mafic and old felsic endmembers, but rather reflects secular variation of trace element ratios derived from the mantle (Albarede and Brouxel, 1987).

ORIGIN OF CONTINENTAL AND VOLCANIC AEROSOLS OF THE VOSTOK ICE CORE (ANTARCTICA)

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The Vostok ice core (East Antarctica) provides a continuous record of continental dusts (2-3 µm) and volcanic tephra (<50 µm) which have undergone tropospheric transport (5000 to 8000 km) and have reached the austral ice cape, during the last four climatic cycles.
For continental dusts, analyses of Sr and Nd isotopes show that they come from Patagonia during both glacial (fluxes of 20 mg/m^2/year) and interglacial periods (fluxes of 1.5 mg/m^2/year). For volcanic ash layers, the combination of Sr/Nd, REE, major and trace elements informations, permits to identify, among the Antarctic and peri-Antarctic volcanic provinces, four main volcanic sources: South Sandwichs Islands, Antarctic Peninsula, Southern Volcanic Zone of South America and Marie Byrd Land in West Antarctica.
Those results show that continental and volcanic aerosols are transported from aereas located, at mid and high latitudes, on the atlantic side of Antarctica, into East Antarctica. This westerlie circumpolare current, with a convergent component toward Antarctica, exist both during glacial and interglacial periods. This reconstruction of large scale paleo-atmospheric circulation permit a better definition of the location and the geomorpholgy of continental dust sources and give new constraints to Atmospheric Global Circulation Models.

SAHARAN WIND REGIMES TRACED BY THE Sr-Nd ISOTOPIC COMPOSITION OF THE SUBTROPICAL ATLANTIC SEDIMENTS.

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New Nd-Sr isotopic data on the <30µm lithic particles of surface and LGM sediments recovered along the African margin between the equator and the Gibraltar Strait, are presented in combination with grain-size measurements. This <30µm size fraction allows us to eliminate any hemipelagic contribution that could occur in the coarser fractions. In the eolian fraction, both Sr and Nd isotopic tracers reveal the same major northwestern origin (Mauritania, Mali, southern Algeria and Morocco). The Archaean formations of the western Saharan shield could be the source of the very unradiogenic ratios observed here. The more southern regions (Senegal, Guinea) act only as secondary sources. A similar pattern is observed for the LGM. Lithic particles are mostly transported by both Trade and Saharan Air Layer (SAL) winds, along an average NE-SW axis; this main feature matches the "southern plume", characterizing the dust transport observed during winter. No significant latitudinal shift of the belt winds is observed between LGM and today. At LGM, however, dust fluxes were 2 to 4 times higher than today, leading to a more "Archaean-type" imprint in the deposits. We do not observe any clear relationship between the latitudinal variability of the upwelling systems identified at LGM, and the location of the major wind systems. Both enhanced aridity on the continent, and increased wind speed probably occurred together over western tropical Africa at LGM.

K-Ar AND $^{40}Ar/^{39}Ar$ ISOTOPIC SIGNATURE OF ENHANCED ICE-RAFTING SUPPLY IN THE NE ATLANTIC.

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Mineralogical, K-Ar and $^{40}Ar/^{39}Ar$ age determinations were carried out on fine grained (<16 µm) silicate fractions of NE Atlantic sediments (47°30'N - 19°30'W) to characterize the changes in source and transport of detrital supply during the phases of enhanced ice-rafting (Heinrich events) of the Late Quaternary. HL_1, HL_2, HL_4, HL_5 (and two older HLs) sediments display equivalent K-Ar and integrated $^{40}Ar/^{39}Ar$ ages within analytical uncertainity which suggests a mixture of Grenvillian (800-1000 Ma) and lower Proterozoic (1800-2100 Ma) minerals originating from the Canadian shield. HLs do not consist in a simple addition of coarse ice-rafted material to ambient sedimentation. In contrast $^{40}Ar/^{39}Ar$ integrated ages are systematically older than K-Ar ages for ambient and HL_3 silicate fractions. The age discrepancy is due to recoil induced ^{39}Ar loss attributed to a volcanogenic component either transported by NADW from the Iceland-Faeroe regions for ambient sediments and/or ice-rafting for HL_3. This component is nearly absent for HL_1, HL_2, HL_4 and HL_5. The isotopic data support the hypothesis of a strong decrease of deep water circulation due to surges of the Laurentide ice sheet in the NE Atlantic basin. However, information on changes in deep water circulation mode during HL_3 cannot be inferred from K-Ar and $^{40}Ar/^{39}Ar$ isotopic data.

STABLE LEAD ISOTOPES CONTRIBUTION TO THE CHEMICAL CLIMATOLOGY OF THE WESTERN MEDITERRANEAN

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Our main objective is to discriminate source inputs from various anthropogenic (industrial, gasoline exhausts) and natural (mostly Saharan dust) emissions to the western Mediterranean to better define the chemical climatology of this enclosed basin. Here we present the first evidence of a clear isotopic discrepancy between anthropogenic emissions from southern France, Spain, Italy and Morocco. This discrepancy is investigated on the basis of gasoline and industrial isotopic signatures as measured in western Europe. Isotopic ratios were determined on aerosols collected concurrently from a French coastal site (Cap Ferrat near Nice) and at sea (transect between Dakar-Senegal and Toulon-France). The $^{206}Pb/^{207}Pb$ ratios appear more radiogenic at sea (=1,155±0,017) than on the coast (=1,137±0,02) suggesting a larger impact of the Saharan dust at sea. Stable lead isotopes were determined from sequential atmospheric sampling (aerosols, filtered and unfiltered rain, bulk deposition) at the Cap Ferrat during specific climatological events (including Saharan dust and anthropogenic plumes) to investigate this difference and trace the processes that control trace metal deposition to fragile coastal environments.

PARTICLE GRAIN-SIZE CONTROL ON THE Sr-Nd AND Pb ISOTOPIC COMPOSITION

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One of the most direct sources of information on paleo-atmospheric circulation is provided by aerosols raised from the continents by dust storms and transported over long distances to the polar ice caps. The clay mineralogy and radiogenic isotopic characteristics of the dust accumulated in GISP 2 ice core (Greenland) and Vostok ice core (Antarctica) have allowed us to identify their origin, from which we can construct the trajectory of the paleo-atmospheric circulation. To use the lithic particles as tracers of the source-areas, it is assumed that their isotopic signal have not undergone chemical and petrological modifications during the phase of deflation, transporation and deposition. To try to answer this particular point, we have studied the relationship between clay mineralogy/Sr-Nd-Pb isotopic system and grain-size fraction of atmospheric dust particles, sampled in possible source areas from around both hemispheres. The systematic analyses of Sr-Nd-Pb isotopic ratios measured on separate size fraction (0-2µm, 2-5 µm, 5-10 µm, 10-20 µm, >20µm) reveal high isotopic variations related to the grain size fraction. The variations for the Rb-Sr system follow the same trend, which can be explained by a mineral partition in the parent rock and a preferential alteration of the 86Sr-rich, 87Rb-poor feldpar in many crustal rocks. For the Sm-Nd and U-Th-Pb systems, the isotopic variations are more diverse and seem to be related to mineral fractionation related to the size.

PROVENANCE OF CLASTIC SEDIMENTS IN THE NORTHERN INDIAN OCEAN: EVIDENCE FROM THE $^{143}Nd/^{44}Nd$, $^{87}Sr/^{86}Sr$ COMPOSITION

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Distribution patterns of $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ for the lithic fraction of Arabian Sea sediments are presented for the sediment surface, the early Holocene and the late Glacial. The Holocene patterns outline a prominent source of dust by northwestely winds from the Arabian peninsula, which dominates sedimentation in the western sector of the Arabian Sea, and a fluvial source by Indian rivers in the eastern sector. During glacial times we observe a third eolian source with dust plumes entering the Arabian Sea from the northwest, i.e. from Iran and the area of the Persian Gulf, which was dry land at that time. Dust raised in East Africa and transported by the low level summer southwest monsoon is not observed and the isotopic composition of sediments in the western Arabian Sea is far from values being typical for the East African basalts. Accordingly, past variations in the composition and mass of eolian particles deposited in the western Arabian Sea are related to climate changes; the dust is not transported directly by the southwest monsoon winds, but by northwesterlies, thus recording environmental changes in the entrainment areas of dust, sea level, and latitudinal shifts of the boundary between the southwest monsoon wind over the ocean and northwesterly winds over the desert.

ON THE ORIGIN OF CONTINENTAL DUST IN THE GREENLAND GRIP ICE CORE BACK TO 44 KYR BP

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Fourteen dust samples extracted from the GRIP ice core (72.6N, 37.6W) [A] have been characterized in terms of mineralogy, Sr, Nd, and Pb isotopic composition, and REE concentrations. The ice samples are taken from the Holocene and from both mild and cold periods during the Last Glacial back to 44 kyr BP. The objective of the study is to determine the variability of the dust composition in relation to climate, and to determine the continental provenance of the dust. The overall mineralogy and the Sr and Nd isotopic composition is similar for all samples, but with some variation in the Holocene. A comparison with samples from possible source areas confirms Asia as being the main source area during the LGM [B]. Preliminary results indicate that Asia is also the dominant source area at other times during the Last Glacial and the Holocene, but with a possible addition of another probably-Asian source in the Holocene.

OA20

REE PATTERN AND ND ISOTOPIC RATIOS OF SEAWATER, FILTERED SUSPENSIONS AND TRAPPED MATERIALS FROM TROPICAL NE ATLANTIC

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Rare Earth Element (REE) concentrations and Nd isotopic ratios were measured for seawaters, filtered suspensions (> 0.65 µm) and trapped materials collected at three EUMELI sites (F-JGOFS: 20°N, 18 ~ 31°W). The $\varepsilon_{Nd(0)}$ values of the seawaters vary with depths and sites (-13.0 ~ -10.5). Those of the suspensions present vertical profiles similar to those of the seawaters, although the $\varepsilon_{Nd(0)}$ values are more negative (-13.5 ~ -11.7). Mean $\varepsilon_{Nd(0)}$ values of carbonate free sediments are more negative than the suspension values at the studied sites (Grousset at al., in press). The intermediate values of the suspensions suggest that the suspended matter contains both authigenic (seawater origin) and lithogenic Nd. Light REE enriched REE pattern of the suspensions supports a preferential uptake of dissolved LREE by the marine particles. Applying the binary mixing hypothesis to the trapped materials, we estimate that 40 ~ 45 % Nd in the large sinking particles is seawater origin. Our results show that the marine particles contain inert lithogenic Nd which allows to trace lithogenic sources. However, they transport also authigenic Nd signals resulting from a surface adsorption and dissolved-particle exchange.

NP3 Transport and mixing in geophysical flows

Convener: Legras, B.

05 Transport and mixing of chemical species in the atmosphere, including urban and regional problems in the troposphere and global-scale problems in the troposphere and stratosphere (co-sponsored by OA & ST)

Convener: Haynes, P.H.

ARIMA MODEL ESTIMATION FOR URBAN OZONE AT THE CANARY ISLANDS AND ITS RELATIONSHIP WITH OTHER POLLUTANTS

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Based on the Ozone hourly data and other different pollutants as SO2, SPM, Nitrogen Oxides and CO obtained at an urban station placed close to a power plant of Las Palmas de Gran Canaria (Canary Islands), an ARIMA model has been determined to describe its evolution. First, trend and spectral analyses using the Fast Fourier Transform (FFT) to detect the different periodicities have been carried out. Once the model has been identified, the different relationship between the Ozone and the other mentioned pollutants have been determined. In order to detect these relations, the Cross-Correlation Functions (CCF) between the different prewithened series have been used. This technique has allowed to determine the characteristic time dependence on each one, caused by the photochemical transformations between the pollutants, showing different lags between them.

RELATIONSHIP BETWEEN TROPHOSPHERIC OZONE AND METEOROLOGICAL PARAMETERS AT TALIARTE (GRAN CANARIA).

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As it has been pointed out in precedent studies, ozone diurnal variations at Taliarte (Canary Islands) are dominated by two different situations: trade winds and marine breeze. Besides, a well-determined relationship between the presence of trade winds and low values of ozone registered at Taliarte, has been found. Multivariate ARIMA model and Cross Correlation Functions (CCF) have been determined to identify the influence of some meteorological parameters in the measured amount of ozone during several situations without the presence of trade winds.

MULTIVARIATE MODEL ESTIMATION USING METEOROLOGICAL PARAMETERS FOR URBAN POLLUTANTS AT GRAN CANARIA (CANARY ISLANDS).

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ARIMA model have been determined for several hourly series of pollutants at Las Palmas de Gran Canaria. Dry temperature, relative humidity and pressure have been chosen as meteorological parameters for the input of the mentioned multivariate model. It has been determined that high values of dry air temperature increase the photochemical transformations between the different pollutants. Also, the dependence of the pollutant transformation and the trade winds have been identified. Finally, stable, high-pressure episodes have been related to the pollutant persistence at the urban atmosphere.

THERMAL INVERSION IMPACTS ON THE MIXING PROPERTIES OF THE LOW ATMOSPHERE WITHIN A DEEP VALLEY

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Pollution problems within deep valley systems are associated to low wind conditions with significant stratification including a strong inversion layer, which reduces the exchanges towards larger scales.
Previous studies have shown that the structure as well as the characteristic scales (height, strength, and duration) of the thermal inversion within the valley strongly depend on the season. These results can be interpreted for urban pollution planning since the dynamics scales are in the same order of the reactive chemical processes.
Our contribution deals with the large eddy simulations of a complete diurnal cycle of atmospheric flows within different schematic valleys. atmosphere.
The main objectives are to point out the influence of the valley aspect ratio and the influence of the shape (convex or concave V or U-shaped valley) on the characteristic scales of the thermal inversion. The impact on the mixing properties of the lowest layers of the atmosphere, linked to the time evolution of the stratification whitin the valley, is shown through the visualization of the iso-concentration of a passive scalar emitted in the centre of the valley during three different periods : at the end of the night (when the thermal inversion is the strongest and when its vertical extension is maximum), at noon (when the inversion is the weakest or completly destroyed), and at sunset.

A TRACER CLIMATE MODEL BASED ON THE LMDZ AGCM

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On the basis of the new LMDz atmospheric general circulation model a tracer climate model has been developped. The implicit scheme of the boundary layer and the convective and advective schemes of the GCM were altered to include passive tracer transportation. Furthermore the possibilities of dry and wet deposition as well as radioactive decay were implemented. The general features of this model have been validated simulating the atmospheric cycles of ^{222}Rn and ^{210}Pb, and lately through the simulation of mineral dust, a tracer of more climatic significance. A special feature of the applied GCM is the ability of applying a stretched grid. This means that the resolution can be increased to near mesoscale over specific areas of interest, with the model remaining global at reasonable computational cost.

TWO YEARS LIDAR AEROSOL MEASUREMENTS AT THESSALONIKI, GREECE

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Measurements of the vertical lower tropospheric profile of the aerosol backscattering coefficient have been performed at the city of Thessaloniki, since 1996 using a ground-based backscattering lidar system operating, simultaneously, at 355 nm and 532 nm. Measurements have been carried out throughout the year around local noon hours and during extensive time periods. The different aerosol loads and their vertical extension in the urban lower troposphere, between the "warm" and "cold" periods over Thessaloniki are discussed. Case studies of the diurnal evolution of the aerosol layer over the city of Thessaloniki have been examined under different meteorological conditions prevailing in the area. From the analysis of these studies the origin of the aerosol layer is indicated and the evolution of the boundary layer over the site is described. Two cases are also presented, when dust lifted from Sahara desert was transported over the measuring site. The height of this layer was determined between 3-4 km and the optical depth at 532 nm of the Sahara dust layer was found to be of the order of 0.1.

MODEL HIERARCHY FOR THE DETERMINATION OF METEOROLOGICAL AND CHEMICAL PROCESSES

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The global, regional and local scale model hierarchy ECHAM-REMO-GESIMA is being developed to improve the understanding of formation processes of photooxidants together with the changing oxidizing capacity of the atmosphere especially in the European/German area. The models are coupled every 6h (global-regional) up to 1h (regional-local) by one-way nesting, meteorology and chemistry is determined simultaneously (on-line).
A summer smog episode in 1994 was chosen for a first application of the mesoscale part of the model system (REMO-GESIMA). Preliminary results focussing on ozone prediction and scale dependence of several trace gas distributions are subject of interest. For the future it is planed to use the complete model hierarchy for analyzing climate and emission szenarios based on global simulations with the climate model ECHAM.

ON THE MODELLING OF CLIMATOLOGICAL CHARACTERISTICS OF PHOTOCHEMICAL SMOG IN BOHEMIAN BASIN

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The transport of air pollution on the regional scale (Bohemian region) is presented. The results of Charles University puff model for the imission assessment are used to give information on the concentration fields of ozone, nitrogen oxides and other ozone precursors. Current version of the model covers up to 16 compounds and it is based on trajectory computation using climatological wind roses and puff interaction both by means of Gaussian diffusion mixing and chemical reactions of species mentioned above. The alternative approach in terms of episodes studies can be solved as well, i.e. appropriate meteorological data can be used to estimate immision characteristics both for episodes analysis and, in case of connection to meteorological model forecast, the prediction of future air quality conditions.

ADAPTIVE PARCEL ADVECTION

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We present a method for performing trajectory analyses using an adaptive irregular mesh to allow refinement of the resolution of the flow. We keep track of nearest neighbours using Delaunay triangulation. Where parcel densities drop below a critical value, extra parcels can be added. Similarly parcels can be removed where the density exceeds a threshold. The critical value can be set using geographical information, (e.g. more parcels in the Northern hemisphere), dynamical quantities (e.g. shear in the flow field), tracer gradients, or other desired parameters. Arbitrary moving boundaries can be included to confine the parcels to a pre-defined region. Variable timesteps are incorporated to allow for the changes in resolution from place to place. The technique can be used in two or three dimensions. We compare two-dimensional results with contour advection calculations by concentrating the parcel density close to a fixed value of a tracer initialized using the potential vorticity on an isentropic surface. The potential for extension of the method to a full dynamical model will be discussed.

HIGH RESOLUTION FORECASTS OF POLAR STRATOSPHERIC OZONE USING THE CANADIAN GLOBAL ENVIRONMENTAL MULTISCALE MODEL

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Preliminary high resolution forecasts of polar stratospheric ozone are presented using the Global Environmental Model (GEM), an innovative model operationally used at the Canadian Meteorological Center. Here we use it in a regional configuration where the resolution is focused over either one of the polar regions, to study the effect of resolution on a simple stratospheric ozone chemistry. Both the sensitivity to the horizontal and vertical resolutions are examined by considering uniform 50 km and 25 km horizontal meshes over the area of interest, and by increasing the number of vertical levels in the stratosphere. The UKMO analyses are used to initialize the dynamical variables of the model while analyses based on total ozone data from the Global Ozone Monitoring Experiment (GOME) provide the initial conditions for chemistry. These univariate analyses of ozone were obtained with a 3D-variational assimilation (3D-var) developed out of the CMC operational 3D-var. The EOF associated to these analyses are also presented to assess the quality of the assimilation system.

RELATIONSHIP BETWEEN METEOROLOGICAL PARAMETERS AND SYNOPTIC CONDITIONS WITH EPISODIC PERIODS AT SANTA CRUZ DE TENERIFE (CANARY ISLANDS)

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Through the use of the data provided by an urban pollutant measurement station placed close to a refinery plant at Santa Cruz de Tenerife (Spain), several high pollutant concentration episodes have been analysed. The data provided by a captive balloon have been plotted on a Skew T û Log p thermodynamic diagram to describe the typical conditions of the lower layers of the atmosphere for each day analysed. Once these conditions have been determined, the synoptic patterns related to all these situations have been identified. A S-SE wind flow related to a high-pressure area placed at the Saharian area gives a subsidence inversion at the lower layers of the atmosphere. Both features depict the typical conditions related to these episodic situations.

OBSERVATION OF ATMOSPHERIC BOUNDARY LAYER CHARACTERISTICS OVER AN URBAN SITE

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The diurnal evolution of urban boundary layer over the central area of Rome was observed by the simultaneous and co-located operation of a Doppler sodar and a microwave ratiometer. The Doppler sodar was configured to provide a wind profile up to about 900 m for every 6 s with a height resolution of 27 m, and a time-height picture of the thermal structure of the urban boundary layer. The radiometer provided a temperature profile up to 600 m for every 120 s with a height resolution of 50 m. The experiment was conducted for a period of 30 days in the years 1996 and 1997. Although the daytime urban boundary layer was mostly characterized by the development of thermal plume structures up to a height of about 700 m, the nocturnal urban boundary layer showed a variety of features including the occurrence of Kelvin-Helmholtz waves, solitary-type waves, multiple-layers, etc. The occurrence of surface-based inversions was found to be rare. The height of the urban boundary laye! r during night-time was around 300 m and was near-adiabatic to isothermal in character. Some typical case studies are discussed.

SENSITIVITY OF OZONE PHOTOCHEMISTRY IN A POLLUTED AREA

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We study the sensitivity of ozone concentrations in an urban area to several parameters using a chemistry-transport box model. First, the influence of meteorological factors such as mean wind intensity, cloudiness and mixed-layer height is examined. Then, various upstream emission rates of nitrogen oxides and hydrocarbons are considered. Finally, we take into account different vertical mixing processes - namely local vs non-local processes - within the urban boundary-layer using the transilient theory approach. The effects of these parameters are studied with respect to the mean chemical reactivity as well as the existence of low and high NOx photochemical states in the urban boundary-layer.

A STUDY OF LAGRANGIAN TRANSPORT IN A WIND DRIVEN, 3-LAYER, EDDY-RESOLVING GENERAL CIRCULATION MODEL USING DYNAMICAL SYSTEMS THEORY

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We study the flow obtained from a 3-layer, eddy-resolving general circulation model subject to an applied wind stress curl. For this model we will consider transport between the northern and southern "gyres" separated by a jet. We will focus on the importance of invariant manifolds in forming geometric structures that govern transport. By "govern", we mean they can be used to compute Lagrangian transport quantities, both deterministic and statistical. We will consider periodic, quasiperiodic, and chaotic velocity fields, and thus assess the effectiveness of dynamical systems techniques in flows with progressively more spatio-temporal complexity. The significance of invariant manifolds as signatures of specific "events", such as rings pinching off from a meansering jet, will also be discussed. The relation of these concepts to potential vorticity dynamics be considered.
This research is supported by the Office of Naval Research through contract number NOOO14-97-1-0071.

DISPERSION THROUGH LARGE GROUPS OF OBSTACLES

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Although there have been many studies of the flow around isolated buildings, much less is known about the effect of groups of obstacles on the flow and dispersion in the atmospheric boundary layer. For many practical calculations it is not feasible to represent all the obstacles individually, and in such cases it is necessary to model the collective effects of the obstacles. The aim of this study is to investigate the influence of the topology of the flow – the convergence and divergence of the streamlines of the mean flow – on the dispersion of a passive scalar. We consider here a two-dimensional flow containing solid squares organized into different regular configurations (aligned, staggered). The mean flow through the group of obstacles is computed using a potential flow model, based on the 'Vortex Panel' method. The turbulent dispersion of a passive scalar from a point source is computed by coupling the mean flow model with a stochastic 'Random Flight' model. We investigate the influence of obstacle size by varying H whilst keeping the porosity constant. In this case the obstacle size determines the spacing between the obstacles. It should also have an influence on the length scale of turbulence, since it can be expected that the obstacles will block motions at scales larger than themselves. The results provide parametric scalings for the effects of configuration and obstacle size on the behaviour of a plume of pollutant

A comparison of flight measurements from Summer '97 with TOMCAT

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In the summer 1997 a large number of aircarft flights took place over the North Atlantic ocean looking at the transport of pollutants from continental regions. The flights were for a number of campaigns including the NERC ACSOE. Measurements of important tropospheric species were made, including ozone, NOx, and carbon monoxide. Our Cambridge off-line 3-D tropospheric model, TOMCAT, was compared directly with the measurements made along flight tracks. TOMCAT has a detailed description of tropospheric chemistry. ECMWF meteorological analyses are used to force the model transport, for the period June to October 1997.
The flights were made in airmasses of different origin exhibiting different chemical signatures.

STRATOSPHERIC OZONE, NITROGEN DIOXIDE and TEMPERATURE MEASUREMENTS at (44N, 11E) DURING 1996-'97

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The future trend of stratospheric ozone at mid and low latitudes is subject of increasing scientific interest. It is a subsequent of the need to clarify better the ozone loses caused by the local processes from the loses invoked by horizontal or vertical transport or from other factors contributing to ozone depletion.
The present paper deals with ground-base measurements of stratospheric ozone, nitrogen dioxide and temperature profile carried out during two years period. The stratospheric ozone and temperature data are collected by means of ECC and temperature sensors mounted on sondes, launched regularly at St.P.Capofiume(44.65N, 11.5N) WMO #297station. The lidar measurements at Brasimone (44.18N, 10.7E) supply upper stratosphere and low mesosphere temperature data. NO_2 data are provided from DOAS measurements in 407÷460nm spectral interval, carried out in Bologna (44.5N, 11.28E) and Mt.Cimone (44.2N, 10.5E)
The obtained experimental data are analysed and compared to satellite data and models predictions to look for transport and dynamic influence upon seasonal ozone variations.

ATMOSPHERIC OZONE LINE OBSERVATIONS IN A FREQUENCY RANGE OF 90-110 GHZ.

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The results of ozone line observations conducted at Nizhny Novgorod (Russia) during 1996-97 are presented. 3^{mm} spectral line radiometer has been employed with the frequency resolution of 2 MHz and system noise temperature of 1200 K. 4 ozone lines were observed with the resonant frequencies of 96228, 101736, 103878 and 110836 GHz as the most intensive lines in operating waveband. Two first lines are observed systematically since February, 1996, till present time. The main objective of this project is to obtain the reciprocal intensities of ozone lines belonging to different transitions. Such measurements are supposed to be informative on the energy levels distribution of ozone molecules. In turn, this is important for an adequate estimation of ozone integral content and density profile. Average measured value of 101736/96228 line intensities ratio equals to 2.11±0.38 in comparison with its theoretical value of 1.8 (under LTR conditions). Two other ratios are 0.55±0.15 (103878 line) and 2.16±0.8 (110836 line) as regards to the same 96228 GHz line. Corresponding theoretical ratios are 0.6 and 2.5. Under observations, a significant deviation in ratios from their mean values were revealed presumably due to changes in physical conditions of atmosphere.

ENSURING ECOLOGICAL SAFETY OF MOTOR TRANSPORT IN URBAN OF CONDITIONS.

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Analysis of ecosystems condition is conducting: "Human being + car + environment" of a city as operating environment of motor transport. Adaptation of operation and system parameters of a fuel supply system of engines of modern cars to the concrete condition of their operating are determined. Structure analysis of mathematical model was made. Foundation of schemes and parameters of pollution indicator of air filters of engine fuel supply system are given. Specified technical actions on raising of ecological safety of modern cars in conditions of city.

STRATOSPHERIC OZONE, NITROGEN DIOXIDE and TEMPERATURE MEASUREMENTS at (44N, 11E) DURING 1996-'97

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The future trend of stratospheric ozone at mid and low latitudes is subject of increasing scientific interest. It is a subsequent of the need to clarify better the ozone loses caused by the local processes from the loses invoked by horizontal or vertical transport or from other factors contributing to ozone depletion.
The present paper deals with ground-base measurements of stratospheric ozone, nitrogen dioxide and temperature profile carried out during two years period. The stratospheric ozone and temperature data are collected by means of ECC and temperature sensors mounted on sondes, launched regularly at St.P.Capofiume(44.65N, 11.5N) WMO #297station. The lidar measurements at Brasimone (44.18N, 10.7E) supply upper stratosphere and low mesosphere temperature data. NO_2 data are provided from DOAS measurements in 407÷460nm spectral interval, carried out in Bologna (44.5N, 11.28E) and Mt.Cimone (44.2N, 10.5E)
The obtained experimental data are analysed and compared to satellite data and models predictions to look for transport and dynamic influence upon seasonal ozone variations.

On the importance of horizontal resolution and mixing in the modeling of the impact of aircraft emissions

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Mixing in the atmosphere is critical for the chemical evolution of the air contained in a plume. In particular, if the mixing is much faster than the timescale associated with chemistry, then it can be expected that the chemical state of the atmosphere will rapidly be equivalent whether the emissions were initially confined to a plume or instantaneously diluted. This dilution is implicitly related to the resolution at which the emissions are distributed in a model. Using a two dimensional chemistry/transport model, the problem of emissions mixing is studied in application to aircraft emissions. The modeled impact of aircraft emissions is shown to be dependent on the horizontal resolution at which the emissions are input into a model. Over the scales and for the conditions studied, the artificial dilution of the emissions due to their inadequate representation in coarse resolution models enables a more efficient reaction from NO_x (= NO + NO_2) to HNO_x (= HNO_2 + HNO_3 + HNO_4).

NP3

TELLURIC LINE OF N_2O AS AN INDICATOR OF ATMOSPHERIC TRANSPORT

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Nitrous oxide rotational lines were calculated using modern *in situ* data on its vertical distribution in Earth's atmosphere. These lines width and intensity subject to variations due to changes in N_2O density profile. In equatorial atmosphere, the mean value of line width equals to ~0.6 GHz insreasing up to ~0.9 GHz at moderate latitudes. This is a sequence of stratosphere being more rich of nitrous oxide in equatorial zone than at moderate latitudes owing to correspondent difference in convection. It implyes the N_2O line possible variations even at moderate latitudes, if the atmospheric transport has changed. This conclusion is supported with the results of N_2O line observations conducted at Nizhny Novgorod (Russia) during March-May of 1997. A 3-mm spectral radiometer was employed with the system temperature as high as 1200 K. The spectra were taken with 2 MHz resolution using the 30-channel filter spectrometer. Nitrous oxide rotational line (J=3→4 transition corresponding to the resonant frequency of ~100,5 GHz) shows variations in its optical depth decrement measured at the frequency shift of 25 MHz from the resonance. During the observations, the decrement has increased by 3-5 times thus implying the significant redistribution of N_2O in a height region of 20÷55 km.

THE SWISS EPFL LIDAR IN THE EU WINTEX PILOT STUDY.

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The contribution of particulate matters as Mie scatters on LiDAR measurements is know to be an efficient tracer for the planetary boundary layer (PBL) height and development in polluted regions. A similar approach was proposed for the WINTEX study in March 97 at Marsta, Sweden, but for very clean boreal air conditions. In case of clouds covering at the height of the inversion layer, this aerosol LiDAR, operated at 532nm (total backscattered) and 355nm (polarized), could follow and retrieve this height, while in clear sky conditions, this PBL height tends to be more difficult to detect. Different meteo conditions will be presented, in particular the increase of the mixing height in the early afternoon due to the solar warming up of the ground.

AEROSOL STUDIES OVER NORTH ATLANTIC

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Concentration and composition of aerosols in the North Atlantic were studied. There are data on particle sizes, contents of C, N, P, Si and Al, results of REM-EDAX analysis. It is showed that lithogenic component contents decrease and organic increase when going off the continents. Comparing of mineral component fluxes from atmosphere to the sea surface with rate of sediment accumulations ("absolute masses") on the floor evidences about important of the aerosols for the ocean sedimentation.

LIGNIN AND PHENOLS IN AEROSOLS OVER CENTRAL ATLANTIC

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It was researched distribution and composition of the lignin and phenols over the Central Atlantic on cross- section (15 N). Content of the identified phenols varies from 35.6 to 588 mkg/g in air-dried matter (2.06-8.09 percents from organic carbon). Calculated content of lignin in the samples is from 83.5 to 3645 mkg/g (16.7-51.9 percents from organic carbon). Prevalence of the p-hydroxyl structures above the vanillin and syring ones is observed in all samples excluding the sample collected near Cape Verde Islands. That relation indicates on transportation by the air masses of large quantity of the plant sporopollenin in which p-hydroxyl structures are dominated. Vanillyl and syringyl structures are in the particles of the higher plant. All noticed components fall on the sea surface and through water column to the bottom sediments, where are preserved for a long time.

COUPLING BETWEEN CHEMISTRY AND MIXING IN A SIMPLE REACTION DIFFUSION SYSTEM

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For many years the environmental concentration of OH has been estimated from the differential change in concentrations of hydrocarbons of differing activity. The normal approach is based on the simplifying assumption that chemical and transport processes are seperated. However consideration of the continuity equation for a reactive species with source and sink terms leads to the conclusion that this simplifying assumption is not generally valid. In this paper new analytic solutions to some steady state diffusion equations will be presented and it will be shown that the seperability assumption of the observational OH studies is valid for all practical purposes. The concept of a coupling constant that is a simple function of the equation constants will be introduced. Finally it will be shown that when values of the coupling constant more appropriate to large scale numerical models are employed the likelyhood of interactions between chemical and mixing processes is much more likely.

ALIPHATIC HYDROCARBONS IN AEROSOLS OVER CENTRAL ATLANTIC

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It was studied distribution and composition of the alkane-naphtene fraction of the organic matter in aerosol samples collected on cross-section from the Mid-Atlantic Ridge (15 N) to Dakar. Contents of the organic carbon vary from 0.84 to 4.45 percents (dry matter), the hydrocarbons - from 91.0 to 1079 mkg/g, the n-alkanes - from 11.69 to 32.02 percents (from hydrocarbon content). Maximums of C25 , C27, C29, C31, C35 and C39 indicating on presence of higher-plant wax dominate in distribution of the biomarkers-n-alkanes. Ratios Pr/Ph vary from 0.87 to 4.17, C10-C 22/C 22-C 40 - from 0.04 to 0.26, CPI - from 2.32 to 6.29. Thus, the continents are source of the terrigenous lipids transported into central areas of North Atlantic by trade winds.

GREENHOUSE GASES IN THE LMD-Z GENERAL CIRCULATION MODEL

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In order to investigate the climate effect of greenhouse gases in an interactive way, greenhouse gases have been introduced in the new version of the general circulation model LMD-Z developed by the Laboratoire de Météorologie Dynamique (LMD).
This preliminary study presents the distributions of CH4, N2O, CFC11, and CFC12 as simulated by LMD-Z.
Surface emissions map for these gases are provided by the up-dated emissions inventories of GEIA and EDGAR.
In this version, chemical and photochemical sinks of the concerned species are calculated off-line with the IMAGES (Intermediate Model for the Annual and Global Evolution of Species) OH distributions and the photodissociation tables obtained with the model MOZART (Model of OZone And Related chemical Tracers). Wet and dry deposition are also taken into account.

SIMULATION OF TRACE-GAS DISTRIBUTIONS WITH THE UIUC 3-D ATMOSPHERIC CHEMICAL-TRANSPORT MODEL AND COMPARISON OF SOURCE GAS DISTRIBUTIONS WITH OBSERVATIONS

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The study of the interaction between climate and chemistry requires the development of fast and accurate submodels that describe photochemical processes and gas transport in the atmosphere. Due to computer time constraints, a number of parameterizations have to be used in such submodels. Accordingly, a detailed validation of the chemical and transport routines should be carried out. One of the best ways of validation is to compare the simulated gas species distributions with satellite climatological datasets. Here we present the 3-D UIUC Atmospheric Chemical Transport model. The model consists of three submodels: (1) A hybrid transport routine, (2) a photochemical routine, and (3) circulation fields generated by the our 3-D 24-layer AGCM. The results of an 8-year steady-state model run are analyzed and the distributions of the long-lived species are compared with appropriate HALOE and CLAES datasets. The simulated monthly zonal-mean mixing ratios of long-lived species are in reasonable agreement with observational data. The correlation between the simulated and observed distributions of long-lived species and the tracer-to tracer correlation show the very good overall performance of the model.

Investigation of high pollution episodes in background regions

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The idea of this study was to investigate high pollution episodes in background regions for most anthropogenic substances Pb, Hg, Cd and benz(a)piren. The study was performed for Borovoe (North Kazahstan) and Lesnoe (Russia) stations.
In the work statistics was calculated, and back trajectory was selected which meets high concentrations.
As a result a relationship between concentrations at observation site and spatial source distribution was found, and environmental conditions in two background regions was compared.

MODELLING THE TURBULENT DISPERSION OF POLLUTANTS IN CITY STREETS

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We need to be able to compute the concentration of atmospheric pollutants in city streets so that we can estimate the impact of such pollution on the inhabitants, so that we can interpret the point measurements provided by static pollution monitors and so that we can estimate the flux of pollutants emitted by the urban environment into the external atmospheric boundary layer. In many practical cases it is possible to idealise a large street as a long, quasi-2D cavity bounded by relatively large buildings. The flow within the cavity is then driven principally by the wind blowing over the top of the cavity, and consists of one or more eddies (depending on the aspect ratio of the cavity) trapped within the cavity. This type of representation is known as a 'street canyon' model. We have developed a new street canyon model which is intermediate between large CFD codes and empirical expressions for the concentration of pollutants. The basic principle of the model is that the flow inside the cavity is computed using a combination of potential flow and fixed, point vortices. The transport and dispersion of material within the cavity is modelled by the advection-diffusion equation, solved by using a conformal transformation to map the physical domain onto the $\phi - \psi$ plane, where we can use standard solutions of the equation. This model gives very good agreement with experimental results for the concentration field in the cavity.

THE ROLE OF REGIONAL TRANSPORT IN URBAN PHOTOCHEMISTRY

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The influence of long-distance transport of ozone and its precursors from remote areas on the photochemical smog formation is examined in different respects. First we demonstrate that it is a dominant effect in the Paris area, which allows one to doubt about the impacts of local traffic restrictions during these episodes. Second we examine in a more general manner the modifications of the local chemical regimes induced by this long-distance transport and show that nox-sensitive photochemical production can happen in certain circumstances even over a large city. We also examine the predictability of the ozone concentrations according to the previous considerations.

PLANETARY AND SOLAR SYSTEM SCIENCES (PS)

PS1 Planetary interiors

Convener: Lognonné, P.
Co-Convener: Gudkova, T.V.

THE MAGNETIC FIELD OF MARS: INITIAL RESULTS FROM THE MARS GLOBAL SURVEYOR MAGNETIC FIELDS INVESTIGATION

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The US spacecraft Mars Global Surveyor was placed in an elliptical orbit around Mars on September 11, 1997. This temporary orbit was designed with very low periapsis altitude transits to carry out aerobraking maneuvers using the spacecraft solar panels with the purpose of reducing its velocity and achieving a 2 PM circular orbit at 350 Km altitude for global mapping purposes. During this initial phase the Magnetic Fields Investigation has acquired data close to the Mars surface establishing unambiguously the presence of a substantial magnetic field of crustal origin. Combined measurements of magnetic fields and electron distribution functions along the orbit have shown that Mars occupies a unique place among the planets in the Solar System. An anomaly with the deployment of a solar panel has required that the mission be replanned including a much more extended aerobraking period which will yield over one thousand additional low altitude passes. This paper will present a summary of the results obtained to date by the Magnetic Fields Investigation and their relevance for understanding the solar wind interaction, interior, crust and thermal evolution of Mars.

THE STRUCTURE OF IRON AT VERY HIGH P AND T

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We investigated the structure of iron up to 2500 K between 30 and 100 GPa in a YAG laser-heated diamond-anvil cell using in-situ angle dispersive X-ray diffraction (beamline ID30 of the European Synchrotron Radiation Facility, Grenoble, France). Our results confirm that iron undergoes a phase transformation for pressures above 35 GPa and at high temperature. The new iron lattice was determined to be orthorhombic with space group Pbcm. The atomic topology is close to that of hcp iron.

Interestingly, we observed significant deviations of the iron orthorhombic lattice from the simple Pbcm symmetry. Unexpected features like additional Bragg-lines or lack of particular dhkl peaks, are often found on the diffraction patterns. These are easily explained and point out a strong flexibility of iron in these extreme conditions. This effect probably affects the physical properties of iron in deep Earth. It also explain ambiguities in previously-reported structure determinations.

CONSEQUENCES OF DIFFERENT VISCOSITY LAWS ON MODELS OF PLANETARY MANTLE CONVECTION

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Using mantle convection models which solve the equations of mass, energy and momentum with either constant, radially temperature dependent or temperature and pressure dependent viscosity and axisymmetric geometry we study possible parameters for viscosity varying from relatively stiff to soft mantle material. These models are applied to bodies with ratios of planetary radius to core radius corresponding to Mercury, Mars and Moon. They are small planets as compared to the Earth with low Rayleigh numbers for the mantle. But the radius ratio of the three bodies differs widely. Mercury's huge core heats the mantle from below whereas the Moon's mantle is mostly heated by radioactive heat sources from within. As for Mars, heating from below and from within are equally important. Temperature at the core–mantle boundary is kept constant and the models describe the state of these bodies after accretion and differentiation into core and mantle. The convection patterns differ significantly for different viscosity laws. Compared to constant viscosity, convection velocity as well as the number of plumes decrease for radially temperature dependent viscosity. In case of additional pressure dependence, convection vigor further decreases, although more plumes appear. In a relatively stiff mantle material heat cannot be transported as effectively as in softer material. This causes a higher temperature difference between up- and downwellings in the former case.

EVOLUTION OF THE MAGNETIC FIELD OF MARS

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Recent data from the Mars Global Surveyor Mission show a strong remnant magnetization of parts of the crust but no dynamo field. This suggests a dynamo field in the early evolution of the planet that later ceased to exist as the core became stably stratified. The transition of the core from convective to conductive depends on the rate of heat transfer in the mantle. We have employed two- and three-dimensional convection models to study the dynamics in the Martian mantle together with the evolution of the core-mantle temperature and core heat transfer. Assuming light elements in the core as suggested by the SNC meteorites, temperatures in the core are high enough to sustain an entirely molten core during the whole evolution. Due to the lack of inner core growth compositional convection which is very effective for the generation of a magnetic field did most likely not occur. Therefore, the early dynamo is likely to have been powered by thermal convection only. We will discuss the influence of the mantle phase transitions on the core-mantle heat transport and a possible magnetic field evolution. In particular the disappearance of an early perovskite layer near the core mantle boundary has been examined.

A POSSIBLE INTERNAL STRUCTURE OF EUROPA

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The Near-Infrared Mapping Spectrometer (NIMS) of the NASA's Jet Propulsion Laboratory's Galileo spacecraft, is being used to study the atmospheric and surface composition of Jupiter and its satellites, as Galileo orbits that planet.
Here in this paper I propose a model for Europa's interior based on the density of Europa (3.0 g/cm3) and recent Galileo data:
the ice crust probably shows part of the history of the internal dynamics when warm liquid water upward plumes reached its bottom leaving minerals deposits through spots and lineas at variated profoundnesses within the icy crust. Comets and asteroids' fragments, gravitationally attracted by Jupiter, were deviated into its Galilean satellites system, since its formation, impacting onto Callisto, Ganymede, Europa and Io; and those impacts onto Europa added great quantitites of carbon compounds-rich material to its sub-surface liquid

LUNAR STRUCTURE AND CLEMENTINE DATA : TEST OF A TECTONIC INVERSION SCHEME

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Generalyzing Clairaut equation leads to the expression of the gravity field, topographies of interfaces, and density lateral variations as functions of the stress tensor field. This is done without any rheological law. If the stress field is supposed to have certain regularities, this leads to an inversion scheme of global data that relies on the determination of the state of stress. We will show the results of the corresponding inversion of Clementine mission topography and gravity data, the main one being that lateral variations of density are needed, in the crust as well as at the top of the mantle, to explain the observed gravity field.

MARS' THERMAL EVOLUTION WITH PHASE TRANSITIONS

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Besides its very known crustal dichotomy, Mars is characterized by two more or less antipodal huge volcanic centres. The first one, located in the Elysium Planitia region, exhibits a relatively short volcanic history. On the contrary, the second one, located in the Tharsis region, shows a very long lived volcanic activity that ended very late in the Martian thermal history. We will present models of the Martian thermal history that could explain these observations. For this purpose we have solved the compressible equations of thermo convection in 2D axisymmetric geometry with a time varying viscosity. The model structure consists in a core of 1750 km large surrounded by a mantle of 1500 km containing decaying radioactive heat sources. We have done two types of simulations in order to compare them. The first one takes into account the presence of the high pressure phase transitions of the olivine to the spinel while the second one has no phase transitions and represents reference models. The main result is that, in presence of the phase transitions, we can identify three stages in the evolution : the first stage, at the beginning of the evolution, is characterized by the presence of two major hot plumes: the intermediate stage is dominated by a unique plume and the final stage shows no hot plumes. This time dependent behavior does not appear in the reference models that exhibit two hot plumes during the entire evolution.

THEORETICAL SPECTRUM OF NEW JOVIAN MODELS

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The oscilation periods for the new models of Jupiter (constructed using Galileo prob data) were calculated for degrees up to 30 and for frequencies up to the tropospheric cutoff frequency. Both gravitational and acoustic modes were considered. The interior models with different size of the core and the position of boundary where the transition of molecular hydrogen into metallic state occurs were investigated. The mass of the core was varied from 3 to 10 masses of the Earth. Three values of the transition pressure 3, 2 and 1.5 Mbar were used. The models had four density discontinuities- at the boundary between inner (IR core) and outer core (IR core and some part of helium), at the outer core boundary, at the boundary where the hydrogen metallization takes place, and at the boundary between inner and outer molecular envelopes (due to the variation of chemical composition). The upper planetary atmosphere levels were taken into account. The results may be useful for properly interpreting the future seismological observations of Jupiter.

TECTONIC DICHOTOMY OF ALL COSMIC BODIES

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More or less elliptic orbits(more pronounced in the past)have all cosmic bodies.It means they have periodically changing cosmic velocities & trajectory curvatures.It causes standing inertia-gravity waves warping planetary spheres in 4 directions(ortho-& diagonal).Superposition of fundamental waves(long $2\pi R$)produces risen(+), antipodal fallen(-)& neutral segments manifested as continental(highland,+)& oceanic(lowland, -)areas(normally in 1:2,2:1 ratios)on surfaces of large bodies and bended shape of asteroids. Uneven inertia momenta of planetary "halves"cause body rolling or rotation.So are tied two universal properties of cosmic bodies:dichotomy & rotation.Impact action as a reason for rotation was discarded by Alfen& Arrhenius(1971). Another consequence of the wave tectonics is standing wave rapid phase change(+ & -):probable cause of magnetic inversions.From left to right:Titania,Iapetus,Mars,Sun(in X-rays).

NEW CONSTRAINTS ON THE COMPOSITION OF JUPITER FROM GALILEO MEASUREMENTS AND INTERIOR MODELS

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Using the helium abundance measured by Galileo in the atmosphere of Jupiter and interior models reproducing the observed external gravitational field, we derive new constraints on the composition and structure of the planet. We conclude that, except for helium which must be more abundant in the metallic interior than in the molecular envelope, Jupiter could be homogeneous (no core) or could have a central dense core up to $12\,M_\oplus$. The mass fraction of heavy elements is less than 7.5 times the solar value in the metallic envelope and between 1 and 7.2 times solar in the molecular envelope. The total amount of elements other than hydrogen and helium in the planet is between 11 and $45\,M_\oplus$.

MAGNETIC SIGNATURES OF THE GALILEAN MOONS OF JUPITER AND THEIR IMPLICATIONS FOR INTERIOR STRUCTURE.

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Significant magnetic perturbations were detected during Galileo's close passes by the large moons of Jupiter. These perturbations give intriguing insight into the structure and dynamic states of the moons. The internal field of Ganymede is well-represented by a slightly tilted dipole moment consistent with dynamo generation in a deep core. The perturbations at Europa and Callisto are dominated by induced magnetic fields that suggest the existence of conducting near-surface oceans. The signature at Io is obscured by large magnetic field perturbations from currents flowing in the surrounding plasma.

PS1

DOES IO POSSESS AN INTERNAL MAGNETIC FIELD?

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The magnetometer onboard Galileo detected a large drop of $\sim$ 700 nT in the field strength in a background field of $\sim$ 1800 nT during its flyby through the plasma wake of Io. Kivelson et al. [1996a,b] have argued that an internal field with a surface strength of at least $\sim$ 1300 nT (equatorial) is required to explain the signature. Frank et al. [1996] on the other hand assert that the signature is produced mainly by the plasma-Io interaction currents. Khurana et al. [1997] recently assessed the contributions to the observed magnetic field from the Jovian magnetospheric field, plasma diamagnetism, the Alfven wing current system and an Io centered internal dipole. We will show that after the effects of plasma diamagnetism and Alfven wing current have been removed from the observations, a depression of at least 400 nT remains in the reduced data. Thus an internal field of the order of $\sim$ 1300 nT (equatorial) seems to be required to model the observed magnetic signature.
We will evaluate the possibility of the generation of internal magnetic field by an MHD dynamo and by simple magneto-convection. We will also discuss the source(s) of energy responsible for convection in the interior of Io.

MODELS OF A MARTIAN REMANENT MAGNETIC FIELD

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In September 1997, instruments onboard the Mars Global Surveyor spacecraft detected the presence of a weak magnetic field around Mars within the first week of its aerobraking operation. As further observations revealed, the Martian magnetic field is not global, unlike the fields of other terrestrial planetary bodies such as Earth or Jupiter's satellite Ganymede. Mars does not have an active dynamo, but its surface is strewn with magnetic anomalies generated by sources in the crust. The existence of these magnetic anomalies shows that Mars once had a liquid core able to support dynamo activity during its early evolution. We will present theoretical models of the global TRM acquisition within the Martian lithosphere, as well as models of the magnetization of localized geologic features, such as the Tharsis Region, and large impact craters, such as the Hellas Basin. The cooling rates of the lithosphere and the initial dynamo field are calculated from a thermal evolution model. In the global models, the calculated surface field strength seems to be consistent with the presently available data. Regarding the smaller scale models of localized geologic units, preliminary results from our calculations will be discussed. As more data will be obtained, we may learn more about the history of the extinct Martian dynamo and the evolution of the lithosphere and crust of Mars.

HOW MANY SEISMOLOGICAL STATIONS ARE NEEDED TO ENSURE BODY WAVE DETECTIONS ON MARS ?

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The presence of a liquid core within Mars would involve the existence of a "shadow zone" where P, S, PcP, and ScS undiffracted phases cannot be recorded. A simple test is performed to check what is the chance of success to detect any event at a number of stations, and to record a number of P, S, PcP, ScS, and PKP phases, using one thousand crustal events randomly distributed in latitude, longitude, and between the surface and 150 km depth. One to four stations are considered. The test is performed for simple three-layered models of Mars. It shows that 4 simultaneously recording stations are needed to ensure at least one detection of either P, S, PcP or ScS waves for any event, and thus to obtain an unbiased estimate of the rate of seismicity. With 4 installed stations, the probability to obtain P and S wave detections at 3 stations simultaneously, and thus to accurately locate the events, is equal to 55%. This probability lowers to a 5% to 30% range with 3 installed stations, depending on the distance between the stations. If these latter are less than 60° apart, the probability is minimum. A distance of 130° between the stations give the best results. With 4 installed stations, at least one PKP arrival is recorded for each event with a chance of success equal to 40%. This probability lowers to less than 2% if 2 or 3 stations are installed. The probability of total failure (no detection at all for a given event) is very small (less than 2%), but not equal to zero, if 3 stations are installed.

The Role Played by Pressure-Dependent Rheology in Controlling Planetary Cooling

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Viscosity of planetary mantles is not only temperature-dependent but very strongly pressure-dependent as well. This point is underscored by the recent laboratory measurements of the activation volume for olivine by Karato and Rubie (1997) for upper-mantle pressure conditions. We have investigated the effect of strong pressure dependece on secular cooling rates of planetary mantel under different dynamical conditions using 2-D numerical convection models. For planetary mantles with a stagnant lid such as on planet Mars, and activation volume values larger than 10 cm^3/mol, we find a penetrative convective style with an immobile bottom layer. Convective flow is concentrated in an intermediate depth level. We find extremely low cooling rates for these models with an essentially conductive bottom layer and a thermal memory longer than the age of the solar system. Primordial thermal conditions appear to be frozen in these models without phase transitions. For the Earth where plate-tectonics operate the effect of pressure dependence appears to be smaller due to a much greater heat loss across the surface boundary layer and an increased heat exchange with the deep mantle related to strong hot upwellings and cold downwellings

IO: A MODEL TO ACCOUNT FOR THE DISCREPANCY BETWEEN HEAT FLOW AND TIDAL DISSIPATION RATE.

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The heat flow from Io poses a problem because it is by about one order of magnitude larger than estimates of the tidal dissipation rate from orbital dynamics. We propose that the currently observed heat flow exceeds by the same order of magnitude the long term average. The present value may be attributed to heat that is stored locally in mantle hot-spots caused by viscous dissipation. We show that viscous dissipation in mantle convection driven by tidal dissipation may cause strong localized maxima in thermal
power density. Energy is conserved because these hot-spots concentrate a fraction of the total power in a small volume. Numerical convection calculations including viscous dissipation show that the power density may locally become as large as $10^{-3} Wm^{-3}$, about 200 times the average power density associated with tidal dissipation. These hot-spots use about 10 % of the tidal dissipation power. The energy may be stored in lava for about 10^4 years and may be released as the lava extrudes at the surface in volcanic vents. Recent observations by Galileo show that most of the vents have temperatures suggesting silicate lava. The energy can then be released at an average rate of a few $10^{14} W$ in about a century. In our model, the core would show alternate phases of rapid heating and cooling and may produce a magnetic field during the latter phases.

MINERAL COMPOSITION AND SEISMIC MODEL OF THE MARTIAN CRUST

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Mineralogic models of the Martian crust are constructed by the method of numerical thermodynamic simulation. The mineral composition of the consolidated crust varies with depth because of a transition of the gabbro-eclogite type. Density and P- and S -wave velocity profiles are computed from the mineralogy. The generally accepted data on the structure of the outer layer of the Moon are taken into account in modeling the outer (10 km), porous layer of the planet. Computations are performed for the compositions of basaltic SNC meteorites (Shergotty, Zagami, EETA 79001 of lithologies A and B), their average composition, and for three variants of the temperature distribution in the crust: with the gradients 21, 13 and 6 K/km. The maximum thickness of the crust is determined from the condition of the its density at the crust-mantle boundary to $3.45 - 3.5 g/cm^3$. The computations showed that, in the event of a cold marsotherm, the crustal density at a depth of 60 km ranges from 3.3 to $3.5 g/cm^3$, and at a depth of 120 km it is $3.5 g/cm^3$. In the case of a hot marsotherm, the density $3.45 g/cm^3$ is attained at a depth of 150 km, $3.5 g/cm^3$, at a depth of 170km. The consolidated crust may be divided into several zones according to the distribution of density and its seismic-wave velocities.

PS2 Evolution and state of surfaces, crusts and lithospheres of planetary bodies

Convener: Janle, P.
Co-Convener: Basilevsky, A.T.

GEOLOGIC MAPPING OF VENERA 13 AND 14 LANDING SITES REGION: VENUS

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The mapping was done using the Magellan photomosaics of Venus surface. The area under study (0-17 S, 291-318 E) includes the Venera 13 and 14 landing sites. The goal of this work is to answer what are the stratigraphic positions of the surface materials chemically analyzed by the Venera 13 and 14 landers. It was found that the stratigraphy of the geologic units of this area agrees generally with the model of global stratigraphy of Venus by Basilevsky & Head (1995). Venera 13 landed near the rift zone extended further to NW and SE including the area of the Venera 14 site. In about 250 km SE of the Venera 13 site there is a pancake dome. Venera 13 landing ellipse is dominated by the lobate and smooth plains (~50% ellipse area) and plains with wrinkle ridges (45-50%). Remnants of densely fractured plains are also present (<5%). The most probable candidates for the material sampled by Venera 13 are the materials of the dominating lobate/smooth plains (young units) or the plains with wrinkle ridges (intermediate age). Venera 14 landed either on or near a large volcanic shield associated with the mentioned rift zone. Venera 14 landing ellipse is dominated by the lobate plains (85-95% ellipse area). Shield plains (5-10%) and remnants of densely fractured plains (<2%) are also present. The most probable candidate of the material analyzed by Venera 14 is the material of relatively young lobate plains.

DETERMINATION OF SURFACE ROUGHNESS OF LAVA FLOWS ON VENUS FROM MAGELLAN RADAR IMAGES

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Between 1991 and 1994, the Venus'surface had been imaged by Magellan Synthetic Aperture Radar in S-band (12,6 cm), HH polarisation and stereoscopic mode with a ~100 m spatial resolution. It appears relatively flat and covered by lava flows.
Our study aims to evaluate the type of volcanic rocks on Venus based on information contained in radar image. The latter is a 2D representation in which geometric characteristics (topographic slope and elevation), surface roughness and electric characteristics of imaged surface depend on wave incidence angle, wavelength and polarisation. In order to determine the nature of rocks on Venus, we must understand the behavior of radar wave when backscattered by the surface in order to modelise it. We analyse thus the relationships between the backscattered radar signal and the local incidence angle from terrestrial radar images obtained by differents sensors and acquisition geometry (Almaz-1, SIRC/XSAR, ERS, RADARSAT), centered on Asal rift (Republic of Djibouti) that can be compared to some extend to the venusian surface. We also used laboratory measurements obtained for experimental surfaces with varying roughness characteristics. By knowing with accuracy the topography and geology of this area, we can test existing radar roughness models for volcanic rocks (from young lava flows to basalt sands) present in Asal rift. Therefore, we extrapolate and inverse this process to determine the nature of volcanic flows on Venus

TECTONICS OF EARTH & VENUS: EXISTENCE OF WAVES M2, S2

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I Terrestrial tectonics is characterised by 'steady-state' convection, manifest by continuous lithosphere plate formation; Venus tectonics, by episodic overturn & wholesale replating of its surface. Additionally the heat loss of Earth (Nimmo/McKenzie,1997) appears to be about twice the radioactive generation rate, whereas loss on Venus is one half this quantity. II The principal terrestrial tides M2, S2 form waves, moving continuously round the Earth (rather than oscillatory geostationary bulging, as in classic models). Shears & translations cancel but stresses rotate without reversal, inducing *cumulative* vorticity. The phase-lag suggests that viscous dissipation amounts to a significant fraction of that under the vortical flow in mantle-convection, conforming with the bias picked up in 'net lithosphere rotation' (Lithgow-Bertelloni; O'Connell; Ricard; others). III Secular wave tides are almost non-existent on Venus due to its slow rotation relative to the Sun, and absence of the Moon. In these circumstances spasmodic convective overturn is to be expected, governed by heat accumulation beneath a static thickening lithosphere. In contrast, on the 'double-planet' Earth the continuous passage of 40 cm waves enhances circulation in the mode manifest as plate motion, accounting for heat-loss exceeding that demanded by the Rayleigh number.

OBJECTIVES OF THE MARS EXPRESS MISSION

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The ESA Mars Express mission includes an orbiter spacecraft and possibly up to four lander modules, to be launched in 2003 by a Soyuz rocket to recover the lost scientific objectives of both *Mars-96* and *Intermarsnet* missions, following the recommendations of the International Mars Exploration Working Group (IMEWG) and of ESA's Advisory Bodies for Mars Express to be included in the Agency's Science Programme. The scientific objectives for the orbiter spacecraft include: global high-resolution photogeology at 10 m resolution, global mineralogical mapping at 100 m resolution, global atmospheric circulation and mapping of the atmospheric composition, subsurface structure at km scale down to the permafrost, surface–atmosphere interactions and interaction of the atmosphere with the interplanetary medium. For the lander modules, the objectives include: internal structure and dynamic activity, meteorology and climatology, landing site geology, mineralogy and geochemistry, physical properties of the atmosphere and surface layers and exobiology (i.e. search for signatures of life). Preliminary design estimates would allow to carry 120 kg of scientific instruments on the orbiter and another 180 kg of lander modules to Mars. Two complementary lander concepts are currently being evaluated, one for geochemistry and exobiology and the other for network science, which could benefit from a number of common spacecraft subsystems. ESA will provide the launcher, the orbiter and the operations, while the lander modules are expected to be delivered by space organisations of ESA member states.

GEOCHEMISTRY OF MARINE SEDIMENTS AND THEIR SIGNIFICANCE FOR STUDIES OF COSMIC FLUXES AND EFFECTS OF EXTRATERRESTRIAL IMPACTS

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Ir has been measured along with other platinum group elements and Au in deep sea sediments recovered by the Ocean Drilling Program (ODP) from the Indian Ocean, the Atlantic Ocean, and the Pacific Ocean. The choice of the Sites located at high northern or southern latitudes or close to the equator provides information on the global distribution of cosmic particle fluxes. In addition, the fractionation of Ir and Au in combination with sediment composition may allow to distinguish between enrichment of siderophile elements by single large impact events and enrichment by changing sedimentation patterns. Constant interelement ratios may indicate a single source whereas changing ratios may reflect fractionation of settling micrometeoritic dust. Taking paleontologic data and sediment components such as clay mineralogy and abundances of shocked quartz into account the effect of cosmic impactor have on the biosphere appears readily assessable. In the presentation the faunal changes at the KT-boundary will be taken as an example to discuss the recent findings.

TOPOGRAPHY OF THE DISCOVERY RUPES AREA, MERCURY

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We produced a 1km per pixel Digital Elevation Model (DEM) of the surface of Mercury (58°W-40°W, 52°S-60°S) using digital stereo analysis. It contains 15 discernible craters ranging from 18-102 km in diameter. A prominent feature in our DEM is Discovery Rupes, a 500 km long lobate scarp, one of the largest tectonic features known on the planet. Lobate scarps on Mercury are believed to have resulted from crustal cooling and compression. A previous estimate of this scarp's maximum relief was as high as 3 km, however our results, covering the high-relief, southern half of the feature give a maximum relief of ~1.5 km and a maximum slope of ~14°. Photoclinometry, using the Lommel-Seeliger/Lambert photometric function, has been used on re-calibrated Mariner 10 images to provide an independent check on these results, and agrees to <10%. The study of this DEM, and future ones that we plan to produce, will improve our understanding of the mercurian crater morphology, may reveal previously unknown basins, and will allow better statistical analysis of lobate scarps, and hence constrain estimates of the decrease in planetary radius from cooling.

CHEMICAL DIFFERENTIATION IN HIGH-TEMPERATURE VAPOR CLOUDS

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Investigations of high-temperature vaporization from various targets show a chemical differentiation for the main elements in the condensates which were collected after evaporation. These condensates are stratified from the first "hot" to the late "cold" layers. The hot part is relatively enriched in refractory elements (Mg, Al, Ca, Ti, Zr) and the cold part in volatile elements (Na, Si, S, K, Fe). Minor elements have a similar asymmetric distribution in the condensates. Usually, these elements follow the temperature curve: refractory minor elements are concentrated in the hot and volatile elements in the cold zones. However, the presence of S, Cl, F and other analogous components in the initial target has a strong influence upon the behaviour of these elements. We examined condensate films from laser-beam evaporation of a picritic gabbro with admixtures of Pt-Pd and Mo-W compounds. The total concentration of these elements in the condensates were lower than in the starting material. However, for sulfur-containing targets they were enriched 3-5 times over the initial composition in the cold part of the condensates. Such enrichments were probably caused by the formation of highly volatile complexes during cooling of the evaporation cloud. Perhaps, the enrichment of the fine fraction of the lunar soil in these elements has the same origin as a result of impact evaporation and condensation.

CHEMICAL DESTABILISATION OF A THICKENED VENUSIAN LITHOSPHERE, UP TO MELTING CONDITIONS. APPLICATION TO MAXWELL MONTES.

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Maxwell Montes is a Venusian high topography, interpreted as the result of a global lithosphere thickening. Our model tends to explain the chronology of compressive and more recent extensive and magmatic events observed on Maxwell Montes. In the lack of water on Venus, its late volcanism must result from a mantle upwelling structure. Therefore, it implies a transition of the convective regime from a downwelling to an upwelling. Our model shows that such a transition can be generated by chemical instabilities of both depleted and basaltic rocks of the lithosphere. On one hand, the depleted and basaltic composition of the lithospheric prevents its recycling during the first few millions years. On the other hand, since the basalt transforms to eclogite, its recycling is all the more enhanced because it is a kept-going process. The root recycling is about twice faster (20 My) than for a purely thermal lithosphere. Moreover, new instabilities may develop in the crustal layer, inducing a new downwelling close to the lithospheric root. In the same time, the recycled depleted rocks are heated enough to generate a chemical diapir which intrudes between the two downwellings. If the internal temperature is high enough, about 80 My after the global thickening, such a feature may provide short time melting and extension underneath the lithospheric root.

A SPECTROPHOTOMETRIC MODEL FOR MARS

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Infrared imaging spectroscopy is one of the priorities for future space missions to Mars (Mars Surveyor program, Mars Express...). The optimization of an observation program, as well as the interpretation of observations, benefits from a model of the signal to be detected.

The present model relies on: 1) Composite reflectance spectra of bright and dark regions, and of the polar caps; 2) A survey of the photometric function of Mars in the literature; 3) A synthetic spectrum of the atmosphere compiled from various sources; 4) A spectral model of emissivity; 5) Variations in Sun-Mars distance with season; 6) Surface temperature range as measured by IRTM.

The surface spectra are composited from space borne observations (ISM and IRS), completed with telescopic observations then scaled to photometric measurements; they cover the range from 0.4 to 5.7 μm continuously. The photometric variations are modeled with IRTM's phase function in the NIR, and with Minnaert coefficients at various wavelengths and phase angles for each type of terrain. The model also accounts for aerosols backscattering.

Results for several situations will be presented, discussed and checked against independent observations.

COMPARATIVE DEGASSING HISTORY OF EARTH AND VENUS

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The thermal and degassing history of Earth and Venus is studied with help of a parameterized mantle convection model including volatile exchange between mantle and surface reservoires. The weakening of mantle silicates by dissolved volatiles may be described by a functional relationship between creep rate and water fugacity. The mantle degassing rate is considered as directly proportional to the seafloor spreading rate and to the melting depth below mid ocean ridges. The rate of regassing depends also on the seafloor spreading rate as well as on the efficiency of volatile recycling through island arc volcanism.

Water from the Earth's mantle outgasses rapidly within a timescale of less than 200 Myr for all numerical simulations. In the case of Venus we find less efficient outgassing up to 500 Myr ago in accordance with data about radiogenic noble gasses. The reason for this effect is the Venusian lithosphere that is more hot and dry than in the case of the Earth.

GALILEO'S VISIBLE-INFRARED OBSERVATIONS OF THE TYRE REGION OF EUROPA

by J.C. Granahan, F.P. Fanale (STI and UH), R. Carlson, L. Kamp, D. Matson, A. Ocampo, W. Smythe (JPL), R. Greeley (ASU), R. Sullivan (Cornell), P. Geissler (UA), J. Moore (NASA Ames), M. Belton, and the Galileo NIMS and SSI instrument teams.

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Tyre, a circular feature on the Jupiter moon Europa, appears to be an impact basin with an approximate diameter of 140 km. This "bulls-eye" patterned feature was observed in the visible by SSI (solid state imager) instrument and in the infrared by the NIMS (near infrared mapping spectrometer) instrument. Unlike the bulk of Europa, the center of Tyre has spectral features of nearly pure water ice. Most of Europa seems to have some hydrated mineral component mixed in with water ice. The implication of these observations is that the impact of Tyre may have excavated pure water ice from below Europa's surface. Later linea forming events superimposed darker colored ridges across Tyre Macula which appear to be rich in hydrated minerals. The youngest ridges which transect this "bulls-eye" pattern (which are only resolved by SSI data) appear to have photometry consistent with that of pure water ice. This suggests that a variety of geologic processes and material reservoirs have been tapped to provide the material which has formed the Tyre region.

EUROPA IN THE PRIME GALILEO MISSION

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Data were acquired for Europa on 9 of the 11 orbits of Galileo around Jupiter, returning 109 images, including some in color and at resolutions as high as 24 m. Preliminary analyses show that the bright plains are composed of multiple ridge sets of a wide range of orientations, and that in the near infrared some plains are dark and others are bright. Processes orginating in the interior (probably heat-driven) lead to the disruption of the bright plains and the formation of mottled terrain. Most observed mottled terrain includes areas of "chaos" in which the plains are broken into individual blocks and plates as small as a few km across, set in a lower matrix of low albedo. Impact craters ranging in size from a ~ 10 m to the 22-km have been discovered. Size distributions vary with terrain, with some of the chaos areas having low frequencies and other units, such as ridged plains, having high frequencies. Concentric fracture patterns >100 km across are also considered impact in origin. Dark halo craters and dark deposits associated other impact structures suggest the presence of widespread dark material less than a few km below the surface.

PREPARATION OF MASSIVE ARTIFICIAL BASALT SAMPLES AS SPECTROSCOPIC ANALOG MATERIALS FOR PLANETARY SURFACES

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Most of the reflectance spectroscopic investigations of planetary analog materials use powdered samples, since common targets of interest in the solar system are covered with a layer of regolith. With the advance of the technology of spectrometers used in space missions, especially in regard of spatial resolution, remote sensing spectra may now be acquired which are dominated rather by outcropping rock than regolith. In such a situation, the appropriate laboratory analog material is of course not a powder, but rather a massive surface, since there are differences in the spectral characteristics of these two cases. The simple approach to obtain massive analog materials is to take bulk samples of natural minerals or rocks. Nevertheless, this severely limits the possibilities, since it is often of interest to investigate mixtures of two or more minerals in varying amounts, a common procedure when working with powdered samples. Therefore, this study investigates the feasibility of the preparation of bulk samples of artificial rocks, i.e. massive surfaces of mineral mixtures. Artificial basalt samples were produced by mixing powders of two different pyroxenes and KBr. This powder mixture was then pressed to massive pellets. The pyroxenes in these samples dominate the spectrum in the near-infrared, as is the case in natural basalts. The KBr has pseudo-liquid properties at high pressures, therefore it provides the matrix in the pellets, substituting the plagioclase in natural basalts. Both KBr and plagioclase have no significant spectral features in the near-infrared.

GALILEO EVIDENCE FOR GANYMEDE CRYOVOLCANISM

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Galileo Solid State Imaging high-resolution data has provided important new informa-tion about the nature of bright terrain on Ganymede and its mode of emplacement. Little evidence has been found for volcanic source vents, embayment relationships, flow fronts. or embayment of bright terrain material into dark terrain topography. Highly tec-tonized portions of dark terrain, and regions of transitional terrain, often appear to be brightened by tectonic deformation rather than volcanism. Tectonic resurfacing may thus be an important alternative to cryovolcanism for the formation of some bright terrain deposits on Ganymede. Evidence for cryovolcanic activity has been found in the form of: 1) relatively smooth plains that do not appear to have originated from tectonic resurfac-ing at least at a resolution of several tens of meters, and 2) features described previously as 'caldera- like' in Voyager images, and imaged at high-resolution in orbit G8. The most prominent of these is a scalloped-walled, internally-terraced depression about 55 km in length and 20 km wide and oriented tangential to a groove lane; the floor of the depression is occupied by a lobate flow-like deposit with parallel ridges oriented con-vexly toward a cross-cutting groove lane. The morphology suggests the possibility of multiple eruptions and thermal erosion. We are presently documenting the relative sig-nificance of volcanic and tectonic processes in the emplacement and evolution of bright terrain.

SYNTHESIS OF GALILEO IMAGING RESULTS FOR GANYMEDE

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High-resolution images of dark terrain provide evidence for 1) heterogeneous albedo patterns, 2) extensive ancient tectonic deformation, 3) furrow morphology and topography consistent with impact origin, 4) resurfacing by impact crater ejecta, but little evidence for plains of volcanic origin; 5) palimpsest structure suggesting that margin is edge of continuous ejecta deposit. High-resolution images of bright terrain provide evidence for 1) Voyager-resolution grooves composed of parallel fractures spaced several hundred meters apart, 2) change in style from early graben to later domino-style tilt block faulting; 3) younger groove lanes tectonically resurfacing pre-existing groove polygons; 4) 'T-intersections' being due to tectonic crosscutting of older terrain by the top of the T, 5) some smooth terrain at Voyager resolution being old and degraded, not young; 6) domain structural trends displaying integrated regional patterns of deformation and some shear; 7) tectonic resurfacing being an important process. Using Voyager data the Galileo groove lane tectonic patterns can be extended to broader regions; these show a systematic change in orientation of stress as a function of time. These data do not favor grooved terrain origin through highly localized or low-strain mechanisms as previously proposed, but favor global models involving changes in figure and global expansion due to differentiation.

LINEAMENT ANALYSIS AND THE ESTIMATION OF THE THICKNESS OF THE LITHOSPHERE IN THE ALBA PATERA REGION, MARS

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Alba Patera is a unique volcanic structure on Mars and even on other terrestrial bodies. Geoscientific modeling until now has suggested two mechanisms of origin: updoming by a mantle plume or volcanic construction. The current available data basis was supplied mainly by the Viking missions with satellite images, topographic and gravity data. A regional lineament analysis resulted in at least three lineament families of different age. The northern part of the radial Tharsis system (Tantalus Fossae, TF) is influenced by the Alba structure. This leads to the conclusion that during the formation of TF a Proto-Alba structure should have existed. The concentric Alba system is younger than most of the radial Tharsis lineaments. This is an indication for a later tectonic phase of the Alba structure. Bending and stress modeling of first radial symmetric loading models can be correlated with the concentric Alba system with an elastic thickness of the lithosphere of about 50km. Older calculations have shown a thickness of at least 150km for the younger Olympus Mons. This difference can be explained by the different age of both structures. Bouguer and isostatic gravity anomalies will be presented. In summary a complex evolution of the Alba structure can be concluded. The bending and stress models are in accordance with a volcanic construction model.

TERRAINS NEAR THE NORTH POLE OF MARS FROM MARS - ORBITER LASER ALTIMETER OBSERVATIONS. EDGE OF THE ICE CAP

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MOLA (Mars Orbiter Laser Altimeter, on Mars Global Surveyor spacecarft) topography measurements presented us with long awaited possibility to measure altimetry variations along and across northern polar ice cap and layered deposits (up to 82N). MOLA has sampled other types of terrain as well. On two tracks near the edge of the ice cap have encountered scarps - 600m and 1km high. In one of the above passes we observed increase of the reflected energy. We interpret this as first laser returns from the residual ice. This correlates well with Viking image of the area for the same season. Data over the trough shows that the north facing slope is less steep than south facing slope. MOLA has also passed over Olympia Planitia, which is known to be covered by dunes. Data shows small topography variations across the area. We plan to present correlations with Shuttle Laser Altimeter data for Sahara dessert.

COMPLEX IMPACT CRATER FORMATION: LARGE TERRESTRIAL CRATERS

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The presented work is a continuation of the project aimed to improve the understanding of impact crater's formation. The variety of different planetary conditions (presence or absence of the atmosphere and crustal volatiles, different gravity at the surface, etc.) results in a specific impact crater morphology. The important problem is to understand which parameters of impact craters reflect physics and mechanics of cratering process and which parameters depend on planetary crust properties. We present the comparative modeling of terrestrial impact cratering events. The large terrestrial impact structures such as Popigay, Chixculub, and Sudbury are compared. On Earth the thermal structure of the lithosphere seems to begin to be important just for craters larger than Popigay (D=100 km). The implications for similar craters on other planetary bodies are discussed.
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PLACE AND ROLE OF TESSERA IN THE GEOLOGIC HISTORY OF VENUS

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Tessera occupies about 8% of the surface of Venus and occurs as a few large clusters centered over regional plateau-like highlands. Unique pattern of features in tessera consists of at least two intersecting sets of ridges and grooves. Almost everywhere ridges are older and grooves are younger. Such an age relationship means two-stage generalized scheme of tessera deformation: i) early compression, ii) late extension. Crater retention age on tessera is about 1.05-1.85T; T is the average age of the planet surface. Duration of the first episode is unknown. Duration of the second episode of the tessera formation was about 10-20% of T. Tessera stopped to form relatively fast before the emplacement of the venusian regional plains. In many large tessera regions, remnants of the tessera precursor terrain have the morphology of smooth plains suggesting that tessera had been formed by the deformation of basaltic material. Tessera is the result of large-scale tectonical shortening of the Venust crust, majority of which has basaltic composition. The shortening was due to mantle downwelling and occurred over vast regions (about several thousands of km). However, the downwelling was localized in a few loci. The process of tessera formation marked the beginning of the visible part of the geologic history of Venus (last 10-20% of the total age of the planet). After the tessera formation, the pattern of the mantle circulation was changed thus the present positive and negative mantle currents do not link genetically with the regional tessera-bearing highlands.

NO ESCERS IN THE VICINITY OF THE SOUTH POLE CAP ON MARS, BUT SOLIDIFIED FOSSIL "TSUNAMIS"

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Some authors have speculated about the possibility of a fossil ice age in the vicinity of the martian South Pole Cap. It has been postulated that the numerous curvilinear ridges in that area might represent very old escers which would proof a fossil glaciation on Mars.

However, careful and detailed investigations of the spatial distribution of those ridges interdict such an interpretation because all ridges in that area trend parallel with respect to the boundary of the entire morphologic unit; escers are never arranged in that way! Hence, in this paper it is proposed that those curvilinear ridges represent a system of tsunami-like waves which got solidified immediately after the mobilisation of a fossil mud sheet flood. The solidification was the result of simultaneous tremendous desiccation and freezing of the surface of the mud sheet flood. The outflow of that mud into the Argyre depression led to the origin of the same type of ridges which form a somewhat triangle-shaped structure in that huge impact depression.

This interpretation leads unevadably to the surmise that the very old Mars had already a very dry and very cold climate with very little air pressure - as it has today.

The consequences for the possibility of (fossil) life on Mars -at least with respect to the ancient martian uplands- are significant.

ON THE ORIGIN OF THE ETCHED TERRAIN, MARS

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The Etched Terrain (=Etched Material) which occurs in the immediate vicinity of the martian South Pole Cap is one of the most enigmatic landscapes of the entire planet. However, if one takes into consideration the possibility that the South Pole Cap got thawed at least one time, then the origin of the Etched Material turns out to be a logic event.

Thawing of the South Pole Cap would lead to the origin and mobilisation of huge amounts of aqueous slurry because the Polar Cap consists of layers of H_2O and CO_2 ice and dust. Moreover, the melting and subsequent collapse of the Polar cap would lead to the origin of huge lumps of still solid material which probably would have slidden northward over short distances, smaller lumps of material even might have flowed like icebergs. Immediately after such an event evaporation and even sublimation of those lumps would have led to the origin of the countless depressions which typify the Etched Material; i.e. these depressions indicate the final position of the "icebergs". Later these depressions got somewhat reshaped by eolian activities.

The spatial distribution of all these depressions which characterize the entire morphologic unit is very telltaling: The by far largest depressions occur in the immediate vicinity of the now existing -younger- South Pole Cap. More northward these depressions soon get smaller and shallower but still form large swarms which occur in the vicinity of the largest depressions. Some individual pits even can be detected within the Argyre Planitia into which a part of the mobilized material flowed. As some of the larger depressions are embayed by numerous small ridges it is indeed very likely that the "icebergs" had at least a tendency to move outward, i.e. northward, which led to the origin of the compressional ridges around them.

CALLISTO MULTI-RING STRUCTURES AND IMPACTOR POPULATIONS FROM GALILEO DATA

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Determining crater frequencies in the Jovian system is important to understanding the surface ages of the Jovian, as well as the outer solar system, satellites. From Voyager data, Callisto (and Ganymede) appear to have a dearth of large (greater than 60 km diameter) impact craters. Galileo SSI images of Callisto's surface have revealed additional candidate multi-ring structures. Although these often lack distinct high-albedo central plains, they can be identified primarily by mapping discontinuous sets of concentric fractures. These additional large impact structures indicate that the population of large impactors in the Jovian system was greater than previously suggested. Impact and other processes have operated on the surface of Callisto over geologic time to erode and nearly obliterate these large structures. This approach in locating large ring structures may aid in the further identification of multi-ring structures in the Voyager data, and lead to better constraints on the ages of the Jovian satellites.

ANISOTROPY OF RADAR PROPERTIES OF VENUS SURFACE

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Some regions of Venus were imaged by the Magellan synthetic aperture radar under two opposite incidence directions. A few sites displayed great difference (up to 9 dB) in the radar cross-section between looks from the west and from the east. This east-west asymmetry of the scattering properties had been attributed to presence of asymmetric microdunes on the surface [C.M.Weitz et al., Icarus 112, 283-295, 1994]. We have performed an exhausting survey and found that small (1-2 dB) east-west asymmetry of the radar cross-section is typical. Independent indications of a north-south surface asymmetry had been obtained from the data of the Magellan radar altimeter [G.L.Tyler et al., J. Geophys. Res. 97, 13113-13139, 1992]. We modelled influence of asymmetric microdunes on radar properties of the surface. We found that variety of microdune fields can account for all observed signs of radar properties anisotropy. We cannot state that all the anisotropy is due to microdune fields; other sources of anisotropy are possible. For some sites of anisotropy, however, there is a set of additional radiophysical and morphological evidences for presence of loose material on the surface, which makes microdune fields a very probable cause of the anisotropy at these sites.

FAULTS AND FAULT PATTERNS OF CONTINENTAL RIFTS OR RIFT-LIKE STRUCTURES ON VENUS, MARS AND EARTH-A COMPARATIVE STUDY

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Several authors have described evidence of continental-style rifting on Venus based on both Pioneer-Venus and Magellan-radar data. Even though, faults, fault geometries and fault patterns of the two most outstanding Venus-rifts Devana Chasma (Beta Regio) and Ganis Chasma (Atla Regio) have not been described in detail, so far. For an inventory of extensional faults and fault patterns of different order the author mapped faults, fault geometries and faults patterns observable on full-resolution Magellan-radarmosaics (pixel size 75 m) covering Devana Chasma and Ganis Chasma. The fault maps of the two Venus rifts are compared with fault maps of two well-known terrestrial continental rifts, Kenya- and Rio Grande rift, at equal scale, to demonstrate similarities and differences in style, geometry and dimension of extensional surface structures and stage of rift development. Finally, the above cited fault maps of venusian and terrestrial continental rifts are compared with a fault map of the widespread rift-like extensional system of the Alba Patera region on Mars compiled from high-resolution Viking-Orbiter photomosaics. Whereas there are obviously, similarities between mapped tectonic characteristics of the venusian and terrestrial continental rifts, mechanisms of upper extensional deformation over the Alba Patera rift-like system are different and difficult to explain. In general, observed lateral differences in style, geometry and dimension of upper crustal deformation along and between venusian, terrestrial and Martian rifts of rift-like structures do reflect or correlate with lateral variations in mantle upwelling and crustal thinning.

SCIENTIFIC RATIONALE FOR THE NEW GENERATION OF LUNAR MISSIONS

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After a gap of nearly 20 years, Clementine initiated in 1994 a new era of scientific investigations of the Moon. This effort will continue with NASA's Lunar Prospector mission (launch in january 1998) and the japanese LUNAR-A misson (launch in 1999). Several projects are under discussion in Europe (Euromoon), Japan (SELENE), and on a longer term NASA's proposals for a lunar base. It is therefore of interest to review the present status of our information on the Moon and the major gaps in terms of remote sensing coverage and in-situ studies.
The scientific rationale for lunar studies can be presented as follows:
- the Moon is an end member of terrestrial planetary bodies, as the smallest and least evolved.
- the Moon forms a binary system with the Earth; many outstanding questions remain on its formation.
- the 5 m thick lunar regolith has recorded the characteristics of the interplanetary medium for most of the history of the solar system (including cometary impacts if the presence of polar ice is confirmed).
The scientific return of planned and proposed missions will be evaluated with respect to these major scientific goals.

RHEOLOGY OF MARTIAN FROZEN GROUND: IMPLICATIONS FOR GLOBAL WATER STORAGE

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Morphological features like fluidized ejecta craters and softened terrains show the existence of large amount of ice in Martian megaregolith. Our purpose is to study the rheology of ice-rock mixtures analogous to the megaregolith in the physical conditions of Mars using constant load tests. The samples consist in frozen cylinder of porous sand saturated by ice. The tested parameters are confining pressure and porosity of samples. Results with porosity of 0.48 confirm previous results about the viscous behaviour of frozen ground and demonstrate the importance of confining pressure. Increase of pressure decreases the influence of microfracturation at high differential stress and increases viscosity of sample at low stress. The decrease of porosity from 0.48 to 0.28 increases the viscosity of the mixture. At porosity lower than 0.28 brittle behavior occurs whatever the physical parameters. On Mars, terrain softening is interpreted as viscous deformation due to groundice. The thickness of ground affected is from the order of 1 km. Our results imply that porosity should be more than 0.28 at 1 km depth and therefore greater than 0.4 at surface following theoritical porosity models. Based on observations, groundice could be present in wide areas on the whole underground of Mars. So taking a large porosity at surface we obtain a global water amount from the order of 500 meters spread over the planet corresponding to the higher limit of previous studies.

DATATION OF COMPRESSIVE DEFORMATION ON MARS: EVIDENCE FOR GLOBAL CONTRACTION

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Compressive structures are well developed on the whole surface of Mars. Stresses due to Tharsis bulge, planetary contraction or volcanic cooling have been proposed to explain this deformation, but none of these hypothesis agree with both models and observations. Our structural analysis focus first on cross-striking ridges in order to find the chronology of deformation events. These observations can be interpreted as the result of a single compressive event in each studied region. We can date deformation using stratigraphical relations and crosscutting relations between craters and thrusts. We find that deformation is restricted to the upper Hesperian epoch in all studied regions. Deformation should therefore be simultaneous on the whole planet. This result is an evidence for a global and single compressive tectonic event. Such event can be explained by global contraction due too cooling of the planet. Consequences of global contraction on martian surface can be examinated evaluating the amount of thermal stress produced by cooling in comparison to the lithospheric strength. Calculations using realistic thermal and mechanical parameters show that global contraction is able to create a single, global and late deformation event with an amount of deformation consistent to that deduced from observations. Agreement between observations, datations and thermal evolution is in favour to the hypothesis of global contraction even if secondary stresses like Tharsis bulge could have an influence on structural trends.

SOME CLUES ON THE ORIGIN OF AUDRA PLANITIA BASIN, VENUS

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Audra Planitia is a small, semi-circular basin in the northern hemisphere of Venus. It is bounded by Kamari Dorsa to the West, whereas it opens toward an area of flat morphology with scattered dorsae and coronae to the East. The floor of this planitia is actually inclined toward the southern margin, forming a very distinct asymmetrical basin, with a difference in elevation of about 1000 meters. Unlike other planitiae, Audra shows remarkable features at its border that provide some clues on its formation. The northern margin consists of extensional faults forming small and shallow graben. The southern margin is more complex and shows interaction between compressional and extensional features. The deformation of the margins seems to have occurred after the formation of the planitia because the extensional features offset the wrinkle ridges present on the basin floor. Audra Planitia probably originated by volcanic flooding over the basement made of complex deformed terrains, Tesserae. Wrinkle ridges formation is linked with this phase. Subsequently, the extension downwarped the basin floor to the South. However, deformation limited to the margins of the basin because most of the planitia seem to be unaffected. The close relationship between the planitia and the extensional features suggests that they are related and represent different stages of an evolving process.

Detectability of sulfates in Martian soils considering different physical soil properties

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Landing sites of Viking and Pathfinder probes exhibit duri-crust like surface properties. Viking inorganic analysis of these crusts point to a high abundance of sulfur whereas the occurrence of other soil constituents suggest that sulfur resides as magnesium sulfate in the Martian soil. Spectral reflectance of powdered and crusted mixtures of bentonite as Martian soil analogues and Magnesium Sulfate as crusting agent was measured in the range of 0.5µm to 25µm. The most significant differences in spectral reflectance between the crusted and the powdered samples appear, beginning at the Christiansen feature at about 8µm, as an increased intensity of the reststrahlenbands of the silicon oxygen vibration modes. Among the influences of the sulfate, there is an increase of water related features in the spectra and the sulfur specific features. Signatures of the sulfates in the spectra below the Christiansen feature are not influenced by the degree of crustfication in the soil models. Ongoing investigation of the crusted samples are aimed to develop methods for detection of crusts and their content in sulfates by remote sensing from the Martian orbit. The Thermal Emission Spectrometer of the Mars Global Surveyor might reveal data for comparison with the laboratory measurements.

Geomorphology of Kasei Valles and scale of flooding episodes

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A Digital Terrain Model covering the two deepest channels in central Kasei Valles has been generated using Viking stereo images. For each image pair, the nominal camera pointing and the spacecraft position data have been corrected with the block adjustment technique using manually collected tiepoints. A large number of additional conjugate points were determined by digital image matching, converted to object coordinates, and interpolated to form the DTM. Using the DTM heights and the hydraulic software FLOWMASTER, we determined the accurate hydraulic radius and derived an optimized estimation for the paleoflow velocities and discharge rates applying the modified Manning equation for Mars. Channel morphology shows that the northern channel is generally not well-defined and it presents an asymmetry between its side walls. Where the channel turns east, it reaches the maximum depth of 1200 m, and becomes well defined and narrow. The southern channel gets also narrow in correspondence to its east turn, however, contrary to the northern one, a geometric difference between the side walls is not evident and the depth of the channel increases downflow reaching a maximum of 2000 m. The maximum flow velocities were calculated for some cross-sections of the northern and southern channels where the channels are well-defined and deep, assuming that the flows were bank-full. The results indicate flow velocities of one hundred to a few hundreds meters per second, and maximum peak discharges of $10^9 - 10^{10}\,m^3/s$.

BOMBARDMENT HISTORY AND AGES OF THE GALILEAN SATELLITES

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During the nominal Galileo mission, high resolution imagery of the three Galilean moons, Europa, Ganymede and Callisto have been obtained which allow to measure crater diameters, in combination with Voyager data, in the size range of ~ 100 m to ~ 100 km. Crater size-frequency distributions are lunar-like. Crater densities on the most heavily cratered regions on both Ganymede and Callisto are fairly comparable. On Europa, crater densities have turned out to be about a factor of 10 lower than on the youngest areas measured on Ganymede. Absolute ages can be derived by either one of two impact chronology models: (1) Model I by Neukum assumes a lunar-like decay with time due to the observed similarity to crater size-frequency distributions found in the inner solar system suggesting the projectiles probably mainly stem from the asteroid belt. Ages on Ganymede and Callisto result as high as ~ 4 b.y., and on Europa ~ 3.0 b.y. and younger. (2) Model II by Shoemaker, however, is based on the extrapolation of an estimated present impact rate of the Jupiter comet family back in time and yields ages for the surface of Europa of only 10 m.y. years, and also fairly young ages for Ganymede and Callisto. Hence, the derivation of absolute ages for the Galilean satellites is still an open issue.

SEDIMENTARY ENVIRONMENTS AND CLIMATIC CHANGES ON MARS

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The past presence of water on Mars has been recognised since the Mariner missions by the presence of channels and river-like features of the surface. Consequently, several small areas has been envisaged as sites of the standing of water liquid or partially frozen. However, the detailed sedimentological and geomorphologic analysis of the Martian surface lead to the idea of the presence of vast zones covered by water bodies as large as the northern hemisphere, north of the crustal dichotomy. The reconstruction of such a large water bodies, that is based on several coastal, is debated but it is consistent with several paleohydrological models and with some paleoclimatic scenarios . The two major problems raised by this interpretation are: the sizes of the lake or oceans and their time constrains, that is their age and their duration. Terraces, and paleoshorelines including spits beach ridges, curvilinear benches and shoreline ridges are the most prominent features indicating the presence of bodies of standing water. Among these features, terraces are rather well defined in the Viking images consisting of flat surfaces adjacent to some kind of highland and boarded toward the supposed body of water by scarps. The age of these sedimentary structures is of paramount importance to identify the timing and tempo of climatic changes on Mars. It appears that climatic conditions suitable for the long-lasting presence of water on the planets occurred several time in the past. Probably the last climatic event of this type is as young as lower Amazonian.

SEARCH FOR CARBONATES ON THE SURFACE OF MARS BY MEANS OF THE PLANETARY FOURIER SPECTROMETER

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An increasing number of geological indications supports the idea that bodies of standing water were once present on the surface of Mars. Because these waters were in presence of a CO_2 atmosphere, carbonate precipitation should have been a very likely process, able to produce thick sedimentary deposits. These deposits could have survived in some ares of the planet, mixed to other components of the Martian regolith. However, despite extensive search for carbonates, up to now no compelling evidences for the presence of these minerals have been found yet.
In this work we present our strategy concerning the spectroscopic search for carbonates by using the Planetary Fourier Spectrometer (PFS) proposed for the payload of the ESA "Mars Express" mission scheduled for the 2003. Various areas of the surface of Mars (craters or depressions), which could harbour large carbonate deposits, are proposed for the search for these materials. Our calculations indicate that in these areas putative carbonate deposits could have survived to the destruction process produced by the UV solar radiation and that the bands at 2.5, 4.0, 7.0 and 11.0 μm, typical of these minerals, can be spectroscopically detected by PFS.

DIAPIRISM AND SOLID-STATE CONVECTION ON EUROPA

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The morphologies of pits, domes, and spots ("lenticulae"), as well as ridges observed in high-resolution Galileo images of Europa are consistent with an origin through diapiric upwelling of warm subsurface ice. Lenticulae are about 10 km in diameter and have morphologies that suggest intrusive deformation of the surface, localized heating, and extrusion. A candidate process for formation of such ice diapirs is thermally induced solid-state convection, predicted to occur within an ice shell on Europa if it overlies a liquid water layer. The morphology of Europa's ridges is consistent with intrusion of tabular diapiric walls that have risen along cracks. An evolutionary sequence is suggested for ridges in which cracks serve to localize diapiric upwelling, diapiric walls upwarp the surface to form a ridge, and ridges subsequently grow in width. Lenticulae and larger regions of chaotic terrain generally postdate ridges; this suggests that the regional geological style of Europa has changed through time, from widespread tectonism (perhaps associated with a thin ice shell) to vertical deformation and broader scale surface disruption linked to solid-state convection. The low crater density and inferred young surface age argues that thermal convection, perhaps above a liquid water ocean, may be an active process within Europa today. Observations from the Galileo Europa Mission will provide further tests of these hypotheses.

LUNAR REGOLITH PROPERTIES AT REINER GAMMA FORMATION

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Spectral mixture analysis has gained wide acceptance and is used to separate the spectral components of lunar soils, mixed at the pixel scale, into percentages of distinct end-members. We implement here a methodology which combines principal components analysis and iterative linear mixture modelling and is applied to the Reiner Gamma region. 3 basic endmembers relevant for modelling the observed spectral variations in the vicinity of Reiner Gamma Formation (RGF) are identified. These are MB (mare background), SWS (south west swirl), and RGS (Reiner Gamma soil). The associated fractional abundance images reveal the existence of a diffuse triangle-shaped unit surrounding the RGF in its vicinity which corresponds to the enigmatic medium-albedo unit, referred to as « red halo » unit in the literature. Two components exhibit spectral characteristics consistent with a prevailing contribution of mature mare soils for the surroundings (MB) and of immature mare crater-like soils (RGS) at RGF. The third intermediate-albedo component (SWS) has general characteristics of a mature mare soil, but with a redder continuum slope. Building upon experimental results produced by laboratory spectroscopic analyses of sieved size separates of soils from Luna-landing sites, it is shown that one can explain the reported observation by a mechanism which would remove the finest fraction in the soil at RGF and redistribute it in the vicinity. This mechanism would be responsible for the disruption at RGF of the optical characteristics of mature soils caused by the natural space-weathering effects.

GANYMEDE DARK TERRAIN MORPHOLOGY AND TECTONICS: RESULTS FROM THE FIRST YEAR OF GALILEO

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During several orbits of the Galileo spacecraft, Ganymede's dark terrain has been imaged at resolutions orders of magnitude higher than those obtained by Voyager. These data have allowed us to reassess the nature of dark terrain on Ganymede, and to evaluate the surface processes which have contributed to its evolution. New Galileo SSI imaging results have shown that the dark terrain is extremely heterogeneous: up to three different plains units are observed; furrow rims and floors can now be distinguished; and bright material is seen in the form of isolated knobs and massifs, plateaus, and crater and furrow rims. We present results which indicate the relative importance of different surface processes including tectonic activity, impact cratering, mass wasting, sublimation, and volcanism. We evaluate models for the origin and evolution of dark terrain and favour one which suggests that dark terrain is comprised of a dark layer of meteoritic material, concentrated on top of a brighter, more ice-rich layer by various processes. We also examine the progression of dark terrain from a relatively pristine condition (e.g. dark terrain in Galileo Regio) to a highly modified state (e.g. fractured dark terrain in the Uruk Sulcus region) and show examples from the recent G7 and G8 encounters. The dark terrain appears to undergo progressive tectonic modification as bright terrain is approached. We also examine the detailed morphology of furrows and use new regional data to reevaluate the centers of furrow systems on Ganymede.

COMBINED REGIONAL ANALYSIS OF GRAVITY DATA AND SURFACE GEOLOGY AT VENUSIAN HOT SPOT PERIPHERY.

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Large topographic rises of the Venusian surface have been interpreted as hot spots (i.e. related to mantle upwellings), based on their topographic, gravimetric and morphological properties. However, some differences exist in these properties from one rise to another. Recent works suggest that they could be related to spatial variations, at global scale, in the Venusian lithospheric properties and/or to temporal variations in the geological activity of the Venusian presumed hot spots.
The present work is an attempt to decipher, at regional scale (hundred's kilometers), the distribution of mass anomalies in the Venusian lithosphere and their possible relation with the major tectonic features associated with Venusian hot spots candidates. It is based on the available high-resolution SAR images and topographic data, and on new high spatial resolution (100x100 KmxKm) gravity anomalies, obtained from local inversion of LOS data. The analysis is mainly realized within the peripheral area of the hot spot (i.e. within the topographic domain of rolling plains), to limit the contribution of mantle dynamics to gravity anomalies. Consequently, one might expect to observe spatial variations in structural lithospheric properties in such areas. The gravity signal is then interpreted in terms of lithospheric, crustal or upper mantle structures and its spatial distribution is established. The produced regional distribution is compared with the spatial and topographic distributions of the geological units and with their stratigraphic relationships.

ORIENTATION AND CHRONOLOGICAL SEQUENCE OF LINEAMENTS ON EUROPA'S WEDGED TERRAIN

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Europas ridges have been observed for the first time by voyager cameras on a global scale and recently by the Galileo SSI camera for selected areas with high resolution. Due to resolution increase and relatively low solar incidence angle, features originating from surface topography are now visible. In this work we will focus on lineaments on Europa's wedged terrain (1) north of Agenor Linea imaged during orbit C3 with a resolution of 420 m/pixel and (2) a terrain imaged during orbit E11 (220 m/pixel), which both reveal frequently resurfaced, partly subparallel ridge structures and seem to originate from multidirectional extension and shear. As a result, many generations of single and parallel ridges with almost chaotic orientation crosscut each other. We will present a map of rigde orientation and spacing for the wedged areas in order to detect formerly related structures. We will also present a chronological sequence of small and intermediate scale lineaments based on detectable crosscutting.

MORPHOLOGY, GEOLOGY, DISTRIBUTION AND AGES OF DOME CRATERS ON GANYMEDE AND CALLISTO

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Dome craters are a class of impact features on Ganymede and Callisto which were first seen by the Voyager cameras and recently observed in higher resolution by the Galileo SSI camera. Such craters are characterized by a morphology somewhat gradational between craters with well-defined rims and palimpsest craters with little topographic expression and may show central pits, domed floors or domed central pits. In this paper we use the extended image coverage on regional scale provided by the Galileo SSI camera in order to map the spatial distribution of dome and domed-pit craters and present detailed geologic analyses of some of those craters imaged at higher resolution. These investigations shed light upon: (a) how large craters in icy surface material form, (b) how crater scaling in ice is compared to scaling on rocky surfaces, and (c), by measuring crater size-frequency distributions of geologic units mapped in dome craters, how the early crusts on both satellites evolved through time. We present two endmember models of how topography of craters is lost: (1) Lesser topographic expression is either related to the crater forming process itself or (2) is caused by modification subsequent to crater formation. Also, (3) a combination of the two processes is possible.

Shape and Topography of Io - Results from the Galileo-Mission

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More than 17 years after the Voyager flybys, the SSI-camera on board of the Galileo spacecraft imaged Io with resolution of up to 2.5 km. The high geometrical precision of the SSI-camera compared to the Voyager Vidicon images, a multitude of imaging opportunities and the broad range of observation geometries allows us to improve photogrammetric analysis of Io's shape and topography. We calculated the three-dimensional coordinates for a net of surface points. Due to its rotation and the gravitational forces of Jupiter, Io's shape is forced into a triaxial ellipsoid. Our results show - in agreement with theoretical expectations - that a triaxial ellipsoid describes Io's shape more accurately than a sphere. The axes found by combining Galileo and Voyager data are: a = 1827.2 km, b = 1820.8 km, c = 1816.9 km. For determining the global topography of Io we fitted spherical functions to the control net of surface points. First hints of large-scale topographic heights and lows exist, but the accuracy of the model has to and will be improved by new data in the next months. On a regional scale Digital Terrain Models of geological interesting areas were calculated. This topographic information was used to describe the relation between volcanoes and lava flows. The slope of lava flows as well as profiles and heights of volcanoes were measured.

HIGH-RESOLUTION GROUNDBASED IMAGING OF MERCURY AT VISUAL AND NEAR-INFRARED WAVELENGTHS

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Very high-resolution imaging of Mercury has been carried out at the 0.50-m Swedish Vacuum Solar Telescope on La Palma, Spain. CCD observations were made with a series of six intermediate-band filters at $\lambda = 450$–940 nm during daytime and twilight at three elongations in October 1995 (central meridian longitude $\omega \sim 270°$), April 1996 ($\omega \sim 120°$) and November 1997 ($\omega \sim 220°$), thus partially overlapping Mariner 10 imagery ($\omega = 100°$). Phase angles were near 90°. The highest-quality data at $\lambda = 550-650$ nm has a diffraction limited resolution of $\sim$ 200 km. Maps of albedo variegation at different wavelengths will be presented.

THE CATASTROPHIC EVOLUTION OF VENUS AND THE CRATERING RECORD

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It was recognized that the tectonic evolution of Venus differed markedly from the earth prior to the Magellan Mission. The images of Venusian craters obtained by Magellan, and their subsequent analysis by *Schaber*, *Strom*, and others, indicated that a near global resurfacing event occurred about 500 My BP. The length of time over which this event occurred has been controversial. Visual inspection of the actual distribution of craters and random simulations cannot be distinguished. However, nearest neighbor analyses indicate a significant divergence from a random distribution of spatially distributed points. We have applied the pair-correlation technique and find that the crater distribution cannot be distinguished from the random simulation. Whereas the pair-correlation considers all possible pairs of points in space, the nearest neighbor technique uses only pairs of points that are closest to each other. We believe the nearest neighbor results are caused by crater interactions and conclude that the resurfacing event occurred over a relatively short period of time. The implications of this conclusion for the tectonic evolution of Venus will be discussed.

IMPLICATIONS FOR THE LITHOSPHERE OF MARS AS A RESULT OF ACCURATE TOPOGRAPHIC DATA FROM THE MGS LASER ALTIMETER

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The laser altimeter on the Mars Global Surveyor mission has provided new and detailed information about the topographic expression and planetary response to many of the large geological structures on the northern hemisphere of Mars These structures, including Elysium, Olympus Mons, Albe Patera, and the north polar layered terrain all show apparent evidence of possible lithospheric loading and flexure with classical moat or tilting of the surrounding surface that extends far from the construct. Some of these flexural features may be partially obscured by material subsequently deposited around the load as a result of collapse or as a result of erosion. Modeling of these structures is suggesting complex explanations for the observations, in some cases very large loads, and providing possible constraints on the structure of the supporting lithosphere. The laser altimeter has already provided topographic information accurate to a few meters along eighteen tracks spaced across the northern hemisphere as far north as 80N. Further mapping of the northern polar regions is expected in the Spring of 1998.

PS3 Atmospheres of terrestrial planets, outer planets and moons

Convener: Hourdin, F.
Co-Convener: Lewis, S.R.

INFLUENCE OF THE BOUNDARY CONDITIONS ON ALMOST RIGID ROTATION OF SPHERICAL LAYER AND EQUATORIAL ACCELERATION OF THE PLANET-GIANT ATMOSPHERES

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The investigation of shear viscous flow in a spherical layer dye to a coaxial rotation of boundary spheres may help to understand some general laws of global motions in planetary atmospheres. The numerical simulation allow to choose the certain process and to consider its on the base of clear mathematical statement under the certain strictly controlled conditions and with the minimum of main assumptions and independent variables. It is known analytical solution (Proudman & Stewartson) in almost rigid rotating spherical layer in the limit of very high Reynolds number and very low Rossby number: thin cylindrical free sheer layer (S-layer) differentiate between the inner inviscid flow with Ekman boundary layers on the spheres and outer rigid rotating area. We investigate the similar solution numerically on the base of Navier-Stokes equations under the rigid and free boundary conditions on the outer sphere. In the first case S-layer lean on the Ekman layers on the spheres, but in the second case S-layer come to the free boundary and result in sharp changing of angular velocity on the surface. It may be the cause of an equatorial acceleration of planet-giant atmospheres.

Role of small components of atmosphere in shaping a surface and of a troposphere of Venus.

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In this work is conducted thermodynamic analysis of system a surface - atmosphere (till the height 42 km) planets with the calculation of flying, in conditions of Venus, of phosphorus oxides. Following resultes were received.
1. As a result of the thermodynamic analysis of the system a surface - atmosphere were calculated the concentrations of the atmospheric components near surface of planet which correspond with the measurementes data. H2O - 6,5 x 10-5 , SO2 - 2,0x 10-5, P4O10 - 2,3x 10-5, CO - 1,28x 10-5, COS - 1,2x 10-5, H2 S - 3,3x 10-6, HCl - 2,3x 10-6, S - 4,1x 10-7, H2 - 6x 10-9, HF - 2,2x 10-9 , P4 O9 - 5x 10-10, CS2 - 1,55x 10-11, SO - 4,0x 10-12 , SO3 - 2,4x 10-14.
2. The possibility of existence hydroxylsilicates (stavrolite) in these conditions is revealled.
3. Hypothetical mineral composition of rocks corresponding to the calculated system of the heterogeneous equilibriums and results of direct measurements of the chemical elementes contents in the samples of Venus rocks, has allowed to estimate by the bound crust of a water mass (~ 4,5x 10+22 g, in the manner of hydro-xylgroups).
4 The possibility of formation at a rate of 11-12 km of traces of aerosol of the layered polymers (P2O5)n is shown.
5. Vertical profiles xH2O, xSO2, xH2S xco, xcos , xs concordant with results of direct measurements in atmosphere is calculated.
6. A possibility of formation above 42 km in the night and impossibility - daytime (near a noon) of the aerosol which contain phosphor is motivated.

References - 23.

ON THE MODEL OF THE TERRESTRIAL GLOBAL CIRCUIT

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A model of the stationary global current circuit in the planetary atmosphere is considered. A contribution of the thunderstorms to the global circuit is modeled by the latitude-dependent radial external non-linear current in the lower planetary atmosphere. An influence of differential rotation of the planet and the planetary plasma envelope is also taken into account in the framework of the planetary electric generator model. Preliminary approach to the description of the electric field generation by the viscous azimuthal magnetospheric flows is developed. Formation and properties of the skin-layer in the region of the upper atmosphere current loop are discussed. Distributions of the electric field and current density in the terrestrial atmosphere is found. It is shown that the approach applied provides the averaged basic parameters of the global current circuit close to the known data on the Earth's atmospheric electricity.

EARTH BASED OBSERVATIONS OF JOVIAN HOT SPOTS IN THE VISUAL RANGE: 1994-1997

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A long term CCD imaging using the 1-m planetary dedicated telescope at Pic-du-Midi Observatory(France) has been employed from 1994 to 1997 to study the Jovian Hot Spots region at 6.5°N, in the latitude of the Galileo probe entry site. The Hot Spots are regions of high 5 μm thermal emission which appear as low reflectivity areas (compared to surroundings) at red wavelengths (600-900 nm). We have used filters isolating these wavelengths (except those corresponding to the methane absorption bands) to track the Hot Spots during this period. We present data on the spatial distribution (number of Hot Spots), evolution and interactions, and motions of individual hot spots. Among other results, anomalous low zonal velocities have been found in a group of 4 hot spots (u = 77 m/s instead of typical velocities of 100 to 105 m/s). We compare the data with long-term 5-μm observations during this same period. Moreover, we advance a 1-dimensional convective downdraft model to explain some of the characteristics observed in these peculiar regions.

GROUND-BASED OBSERVATIONS OF TITAN'S SURFACE

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Observations of Titan in the near infrared have been continuously exercised from the ground since almost a decade now, bringing new, exciting information on the nature of the satellite's surface. In combination with images from the HST, the data help acquire constraints for modeling the possibilities of a ground which has avoided direct detection even by space missions.
This group has performed spectroscopy and imaging in the 0.9-2.5 micron region by using different techniques and instruments such the Fourier Transform Spectrometer (FTS) at the CFHT (1991-1996), the ADONIS camera at ESO (1993-1997) and the PUEO adaptive optics system at CFHT (1997). The combination of the data obtained by these methods yield information on the Titan's geometric and surface albedo, on the lightcurves, on the ground topography and on the possible constituents on the surface (Coustenis et al, 1995; 1997; Combes et al, 1997).
We will give a report on the *state of art* of our current comprehension of the still viable models of the satellite's surface, based on these observations.

A RADIATIVE-CONVECTIVE/PHOTOCHEMICAL MODEL FOR TITAN'S ATMOSPHERE

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A radiative-convective/photochemical model is being developed to examine the processes which determine the thermal and compositional structure of Titan's atmosphere, in anticipation of the Cassini Mission results. The model uses a pressure grid and extends from the surface to 800 km. The photochemical model can include upto 60 chemical species in an unlimited number of reactions including ionisation by solar radiation upto Lyman beta. Initial work has involved the generation of the vertical temperature structure of the troposphere, stratosphere and upper atmosphere, in order to understand the main radiation transfer processes governing the thermal structure of the atmosphere. The emphasis has been to explore the possible atmospheric heating mechanisms, especially methane absorption of solar radiation and ionisation heating in the upper atmosphere.

GCM SIMULATIONS OF THE DUST CYCLE ON MARS

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The amount of dust which is lifted and transported by the martian atmosphere is one of the most variable components of the Martian environment, with a strong seasonal cycle, considerable year to year variations and large spatial variations. By its radiative effects, the martian atmospheric dust plays a major role in determining the climate on the planet. To improve our knowledge of the dust cycle on Mars, and better simulate the related changes in the environmental conditions, we have included an interactive dust transport model in our atmospheric general circulation model (GCM) of the martian atmosphere. The resulting model is able to simulate the lifting of the dust by the near surface winds, the vertical mixing in the turbulent boundary layer and by atmospheric convection, the advection by the general circulation, and gravitational sedimentation. This model is used to study the various mechanisms that control the seasonal cycle, initiate the global dust storms, and possibly account for the interranual variability of the climate.

THE ABUNDANCE OF CO IN THE LOWER TROPOSPHERE OF TITAN FROM 1.6 MICRON SPECTROSCOPY

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High-resolution spectra of Titan near 1.6 μm were recorded at the IRTF in August 1993. They show detailed structure associated with tropospheric absorption on Titan, as well as solar and telluric features. Because of the high spectral resolution, the solar and telluric features can be fairly easily modeled out. The resulting Titan spectrum contains five well contrasted lines from the 3-0 band of CO, and weaker CH_4 absorption features. The absolute flux scale, however, remains undetermined. On Titan, near-IR radiation is scattered by haze particles and reflected by the surface. Various constraints exist on the haze properties and on the global reflectivity. We rely on the haze model of McKay *et al.* (1989) and on measurements by Coustenis *et al.* (1995). Fitting both the geometric albedo and the CO line contrast requires a surface albedo of 0.10–0.20, in combination with a haze distribution that is slightly depressed compared to the nominal model. We find a CO mole fraction of $(5.5\pm 2.0)\times10^{-5}$ in the lower 60 Km. This value is in agreement with the early determination obtained by Lutz, de Bergh and Owen (1983). It is also consistent with the values derived above 60 km from millimeter line measurements (Gurwell and Muhleman, 1995; Hidayat *et al.*, 1998). It is, however, incompatible with the abundance inferred by Noll *et al.* (1996) from observations in the 5 μm window.

ELECTROSTATIC CHARGING PROCESSES IN PLANETARY ATMOSPHERES

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Electric currents and quasi-static fields induce asymmetries in the properties of planetary atmospheres. Bodies moving against the electric field collect an excess of positive ions and therefore develop positive potentials; bodies which move along the field acquire a net negative charge and may develop negative potentials. It is frequently observed in the Earth atmosphere that balloons and gondolas have positive potentials during their ascent, but not during their descent. Similarly, aerosols carried by atmospheric uplifts transport positive charges, whereas large falling droplets are charged negatively. This process may be responsible for the charge separation which takes place within clouds and leads to thunderstorms. Measuring the potential of bodies ascending or descending in a planetary atmosphere will therefore reveal the existence of electrid fields and currents; the possible consequences for the Huygens Probe which will parachute through the atmosphere of Titan, the largest satellite of Titan, in 2004, are discussed.

A MODEL FOR CHLOROACETALDEHYDE SYNTHESIS FROM ATMOSPHERIC PRECURSORS IN THE PRIMITIVE EARTH

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Chloroacetaldehyde may have been an important prebiotic compound since it may react with cyanide aqueous solutions to yield acetyl cyanide, a powerful acetylating agent. We are conducting a systematic search of gas-phase as well as aqueous-phase reaction pathways leading to chloroacetaldehyde synthesis in the primitive Earth. One possibility is that chloroacetaldehyde was formed in aqueous solution from vinyl chloride and HOCl, although other pathways are equally possible. In this work we suggest that HOCl and vinyl chloride can be produced photochemically from HCl and acetylene. In analogy with Venus chlorine stratospheric chemistry, two important chemical pathways may transform HCl into Cl: 1) direct photolysis of HCl by UV radiation, and 2) reaction of HO_x radicals with HCl. Once Cl is available, HOCl can be produced by recombination of Cl with OH and, analogously, Cl_2 is formed when two Cl atoms recombine. Addition of Cl to the acetylene triple bond followed by H abstraction yields vinyl chloride. A zeroth-order evaluation of wet removal lifetimes for vinyl chloride and molecular chlorine has been carried out. Our results predict a significant production of chloroacetaldehyde from atmospheric precursors provided that adequate sources of acetylene and Cl were available in the prebiological atmosphere.

CRYOVOLCANISM ON EUROPA: GALILEO RESULTS IN THE NOMINAL MISSION

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Imaging data for Europa were acquired on eight of the orbits of Galileo around Jupiter, providing new insight into the nature and evolution of the surface. A variety of surface features have been identified that can be attributed to cryovolcanic processes (involving the generation of ice-rich magmalike materials in the subsurface and their emplacement on the surface). These features include small, flat patches (possible frozen ponds), surface RblistersS which could represent surface deformation by diapirs (Pappalardo et al.), glacierlike masses which appear to be material extruded on the surface, and small (10-16 km), aligned dark spots which could represent explosive venting.

A TERRESTRIAL CLOUD ENSEMBLE MODEL TO STUDY THE ATMOSPHERES OF THE GIANT PLANETS

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The atmospheres of the giant planets are different from that of the Earth in three ways: (i) They have no surface. (ii) They possess a significant internal heat flux. (iii) Condensates are heavier than hydrogen and helium, hence moist air is denser than dry air. A 3D cloud ensemble model successfully applied to the Earth's tropics is used to study the impact of the condensates' large molecular mass on atmospheric convection. The model consistently predicts temperature and mass mixing ratio profiles. An experiment consisting of arbitrarily increasing the mass of the molecule that condenses (water), thus mimicking the large water to hydrogen mass ratio relevant of the giant planets, shows a progressive increase of the temperature gradient (i.e. the temperature profile becomes steeper as moist air becomes less buoyant). It is also seen that temperature perturbations become more important in order to balance the stabilising compositional gradient. This has important consequences for our understanding of the atmospheres and interior of Jupiter, Saturn, Uranus and Neptune, and in particular for the analysis of spectroscopic data in regions of cloud formation.

DYNAMICS OF TITAN'S ATMOSPHERE : IMPLICATION OF TRANSIENT ACTIVITY FOR THE SUPERRORATION AND TRANSPORT OF TRACE SPECIES

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The dynamics of the stratosphere of Titan is believed to be dominated by a strong Venus-like superrotation with zonal winds of the order of 100 m/s near 1 mbar, corresponding to about 10 times the rotation of the solid planet.
Transient quasi-barotropic eddies transporting angular momentum toward the equator, against the mean meridional gradient, play a major role in the angular momentum budjet and in the maintenance of superrotation. A detailed study of those waves is undergoing in the frame of a collaboration between LMD and Faculdade de Ciencias de Lisboa.
We present some first results of this study as well as a dicussion of the implication for the meridional transport of trcae species in Titan's atmosphere.

PRESSURE OBSERVATIONS IN THE MARTIAN SOUTHERN POLAR REGION: MVACS /MET-P

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Pressure observations are crucial for the success of the Meteorology (MET) package for the Mars Volatiles and Climate Surveyor (MVACS) expected to land on Mars in December 1999 ($L_s \approx 257°$), nominally to the location 71°S, 210°W.
The Martian atmosphere goes through a large scale atmospheric pressure cycle due to the annual condensation/sublimation of the atmospheric carbon dioxide. Pressure also exhibits short period variations associated with dust storms, tides, dust devils and other atmospheric events. A series of pressure measurements can hence tell us about the large scale state and dynamics of the atmosphere. The shorter time scale phenomena are also important in contributing to our understanding of mixing and transport of heat, dust, and water vapor.
The sensing element of the MET-P will comprise four Barocap radiosonde type sensors manufactured by the Vaisala Inc. Similar sensors were used in the Mars-96 landing elements, and will also fly onboard the Huygens/Cassini as a part of the atmospheric structure instrument.
The characteristics of the seasonal and shorter term pressure variations anticipated to take place place at the MVACS landing site, the design of the MET-P instrument and the predicted performance thereof are discussed.

GALILEO/NIMS DETERMINATION OF THE DEEP COMPOSITION AND CLOUD STRUCTURE OF JUPITER

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The Galileo Near Infrared Mapping Spectrometer (NIMS) recorded the first ever complete spectra of the atmosphere of Jupiter from 0.7 to 5.2 μm at a resolution of 0.025 μm without the contamination of terrestrial absorption. We have analysed a subset of these data with a full multiple scattering model utilising correlated-k and the matrix operator method. Cloud particles were modelled as Henyey-Greenstein scatterers with spectrally dependent properties similar to Mie spheres of real possible cloud constituents.
We find that at least three cloud layers are required to simulate the near-infared spectra of Jupiter with cloud bases near 1.35, 0.7 and 0.2 bars. The dominant 5-μm absorber is determined to have a flat 5-μm absorption spectrum and to exist at some level between these clouds and the peak of the 5-μm weighting function at 6-8 bars. Large NH_4SH particles are considered to be the most likely candidate.
We find that the volume mixing ratios of CH_3D and PH_3 in the 2-6 bar range are 4.9×10^{-7} and 7.7×10^{-7} respectively and that the fractional scale height of PH_3 above 1 bar is approximately 27%. The relative humidities of water vapour (2 - 6 bar) and ammonia are determined to be 7% and 14% respectively with the latter showing a significant anti-correlation with mean 5-μm brightness, consistent with the proposal that these are areas of dessicated downwelling air.

EVIDENCE FOR A STRONG $^{15}N/^{14}N$ ENRICHMENT IN TITAN'S ATMOSPHERE FROM MILLIMETER OBSERVATIONS

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We present heterodyne observations of Titan performed with the IRAM 30–m telescope in July 1997. Two lines of hydrogen cyanide were simultaneously recorded at high spectral resolution in order to infer the isotopic ratio $^{14}N/^{15}N$. The lines of $HC^{15}N$(3–2) at 258.157 GHz as well as that of $HC^{14}N$(1–0) at 88.63 GHz were measured with a high signal–to–noise ratio. Analysis of the HCN(1–0) line yields a HCN vertical profile in excellent agreement with that proposed by Hidayat *et al.* (1997, *Icarus* **126**, 170). Moreover, the data recorded at the highest resolution (78 kHz) provide constraints on this profile up to an altitude of about 450 km, assuming a nominal thermal profile. This distribution was used to accurately derive the $HC^{14}N/HC^{15}N$ ratio. Direct comparison of measured spectra with synthetic appropriate calculations shows that this ratio is equal to 60 within 10% uncertainty. We conclude that Titan's atmosphere is highly enriched in ^{15}N by a factor of 4.5 as we consider the terrestrial value of 272 for the $^{14}N/^{15}N$ ratio. Titan is therefore the second object in the Solar System, after Mars, which presents an isotope anomaly in nitrogen. Although the enrichment factor of 1.62 existing on Mars is not well interpreted by the current models, we used similar hypotheses to first explain our result. In fact, such models cannot predict adequately the strong enrichment observed on Titan. Other considerations on nitrogen isotope fractionation are thus discussed.

OPACITY OF THE MARTIAN ATMOSPHERE FROM MARS ORBITER LASER ALTIMETER OBSERVATIONS

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MOLA (Mars Orbiter Laser Altimeter) has performed a unique measurement of the reflected laser energy from the underlying terrain. This quantity can be interpreted as a product of albedo of the surface(A) and atmospheric transmission ($e^{-2\tau}$), where τ is opacity. We decided to use Viking Orbiter Color Mosaic images (red filter) as a first order estimate for the albedo of the surface. Using this estimate we are able to calculate atmospheric opacity. We have performed this calculation for several tracks that occurred north of the Elysium region. We will present comparisons of calculated opacity with observations by Viking 2 lander, which is in the same region. Tracks were separated in time by one Martian day and cover almost two months ($L_s = 180 - 210$). Data shows an increase in opacity of the atmosphere with time. This is expected, since the dust storm season is approaching. Also, opacities for the equatorial regions are lower than we expected (0.2-0.25). We have also observed sudden decreases in the reflected energy, which can not be explained by albedo variations of the surface. We argue that this is due to the water clouds, which are known to form in the northern regions of Martian atmosphere. An analogous event happened over the Valles Marineris canyon. We suggest that the laser beam is scattered by the late afternoon fog in the valleys.

A PLAUSIBLE VERSION OF PLUTO'S ATMOSPHERE

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We assume that the observed bottom of the atmosphere at r = 1198 km is a tropopause where N_2 is saturated at T = 35.2 K and p = 3.1 μbar. The troposphere with wet adiabatic gradient of -0.1 K/km extends down to the surface at r_0 = 1164 km where T_0 = 38.6 K and p_0 = 26 μbar agree with the measured value of 40 ± 2 K and the N_2 saturation condition. The observed CH_4 should be corrected to these temperatures and has a mixing ratio of 0.006. Photolysis of CH_4 occurs at 1550-1600 km, and molecular diffusion prevents depletion of methane. Condensation of photochemical products (hydrocarbons and nitriles) at $T \approx$ 100 K is not so effective as on Triton, and photochemistry is more similar to that on Titan. Photochemical haze may include species absorbing in the near ultraviolet and affecting the thermal balance at 1200-1400 km. Methane abundance exceeds by twofold that in the best model of Strobel et al. (*Icarus 120,* 266, 1996), therefore CO (which cools the atmosphere) is also doubled to 0.001. Escape of CH_4 is diffusion limited at 2×10^{26} s^{-1}. Diffusion separation of CH_4 is ineffective, and methane is a minor species in the thermosphere. Modeling of heating by methane at 100-140 nm results in $[N_2] \approx 3.4\times10^{10}$ cm^{-3} and $T\approx$ 135 K at 1900 km. EUV global-mean heating by N_2 is 3×10^{-4} erg $cm^{-2}s^{-1}$ (ε = 0.25). Using the McNutt approximation, we find the N_2 escape of 2.5×10^{27} s^{-1}.

DETECTION OF ATOMIC DEUTERIUM ON MARS

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We observed Mars at 1212-1218 Å with resolution of 0.07 Å during 1.57×10^4 s using the HST Goddard high-resolution spectrograph. The instrument field of view of 1230×1230 km^2 was centered at the martian limb. Mars had geocentric velocity of -15.4 km/s, was near aphelion at the solar minimum, and the expected $T_\infty \approx$ 180 K. The observation revealed Mars' deuterium Ly-α line with intensity of 23 ± 8 Rayleighs. To reproduce the measurement, we constructed a model with HD density at the lower boundary of 80 km as the model parameter. HD forms D in reactions with CO_2^+, O^+, and $O(^1D)$. We consider nonthermal escape of H, H_2, D, and HD which was ignored in previous models and is a dominant loss mechanism for H_2, D, and HD at solar minimum. We applied the model results to a radiative transfer code in spherical atmosphere. The measured intensity corresponds to $HD/H_2 = (2.5 \pm 1)\times10^{-4}$ at 80 km which is smaller by a factor of 6 than HDO/H_2O in the lower atmosphere. Therefore, fractionation of HD/H_2 relative to HDO/H_2O is not kinetically controlled by the rates of formation and destruction of H_2 and HD, but is controlled thermodynamically by the isotope exchange $HDO + H_2 \leftrightarrow HD + H_2O$. The escape ratio Φ_D/Φ_H:$(D/H)_{H2O}$ is 0.02 for mean solar activity.

High-altitude haze effects on Titan's atmosphere

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We have investigated the role of aerosole particles in the atmospheric energy balance in the upper atmosphere of Saturn's large moon Titan. In our analysis the aerosole particles absorb solar radiation, emit in the infrared (IR), and are energetically linked to the surrounding gas by thermal conduction. We investigate the order of aerosole heating/cooling in Titan's upper atmosphere from 450 km up to 700 km. Our results suggest that aerosole heating/cooling may influence the energy balance of Titan's upper atmosphere.

MODELING THE SEASONAL VARIATIONS IN TITAN'S ATMOSPHERIC COMPOSITION

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In order to model seasonal and latitudinal variations of the composition of Titan's atmosphere, we have used an updated photochemical model based on *Toublanc et al.*, Icarus 113,2-26 (1995), taking into account the seasonal cycle at different latitudes, and in a first step, no general circulation was added. To model high latitude winter conditions, more realistic photolysis rates have been obtained using a 3D radiative transfert Monte-Carlo code. Atmospheric composition is computed for the four seasons, at latitudes from the equator to 70°. These results are presented and discussed in comparison to Voyager observations (*Coustenis et al.*, Icarus 115, 126-140 (1995)). Possible effects of the general circulation are also discussed.

SPACE TELESCOPE IMAGING SPECTROGRAPH OBSERVATIONS OF THE TROPOSPHERE AND SURFACE OF TITAN

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Spatially resolved spectra of the bright and dark sides of Titan were obtained in the 0.3- to 1.0-μm range by the Space Telescope Imaging Spectrograph (STIS). The difference spectrum (bright - dark) is the product of the difference in surface reflectivity and the atmospheric transmission. Methane absorption dominates the atmospheric extinction: the width and shape of each of the methane windows constrains the methane abundance. Preliminary analysis of the methane window shape suggests 3.5 km-Am of methane (or about an 8% mixing ratio at the surface). Uncertainties will be investigated and presented. The signal from the surface declines with decreasing wavelength: in large part, this must be due to increasing haze opacity at shorter wavelengths, but the possibility of a wavelength dependent surface spectrum will be investigated. At the center of the disk, the surface signal is observed at wavelengths as short as about 0.6 μm away from the center, the surface is only seen at wavelengths greater than about 0.7 μm. Note that the observed surface signal is the difference between two regions that are nearly the brightness extremes, and do not necessarily reflect contrast over small spatial scales.

NUMERICAL MODEL OF THE ATMOSPHERIC CIRCULATION OF THE OUTER PLANETS

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We present some results on the numerical simulation of the atmospheric circulations of the outer planets of the Solar System, taking into account the inclination of their rotation axis with respect to the ecliptic plane (which implies a different latitudinal mean solar heating).
For small angles (such as 27 degrees, which corresponds to Saturn and Neptune), the dynamics is not strongly affected by the inclination, apart from certain features of the momentum and heat transfers. On the contrary, when the inclination is 98 degrees, as is the case for Uranus, the dynamics is completely changed. In particular, the temperature field has no radial variations and the sign of velocity field is opposite to the Jovian circulation.

VALIDATION OF A MARTIAN GENERAL CIRCULATION MODEL AGAINST RECENT OBSERVATIONS FROM MARS PATHFINDER AND MARS GLOBAL SURVEYOR

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Martian General Circulation Models have been developed jointly between Laboratoire de Météorologie Dynamique du CNRS, Paris, and Atmospheric, Oceanic and Planetary Physics, Oxford. Results from these models form the basis of a climate database, described in a companion paper (Lewis *et al.*). The models have been calibrated using the few direct observations of the Martian atmosphere; mainly measurements made by the Mariner 9, Viking and Phobos spacecraft. However, current and forthcoming missions will provide much new data against which the models may be tested.
This paper describes a direct comparison made between the Oxford model and observations of temperature, wind and pressure from Mars Pathfinder. Many aspects of the observations are also present in the model; some significant differences may be ascribed to lack of knowledge of the topography and surface properties and to the scales of motion which the global model is able to represent. Preliminary temperature soundings from the Thermal Emission Spectrometer onboard Mars Global Surveyor have also been released and these are compared with model predictions. The level of agreement depends upon the assumed model dust distribution, and is consistent with independent estimates.

A CLIMATE DATABASE FOR THE MARTIAN ATMOSPHERE

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A database of statistics which describe the climate and surface environment of Mars has been constructed based directly on output from multi-annual integrations of two General Circulation Models developed jointly at Laboratoire de Météorologie Dynamique du CNRS, Paris, and Atmospheric, Oceanic and Planetary Physics, Oxford, with support from the European Space Agency. The models have been validated to reproduce the main features of the meteorology of Mars, as observed by past spacecraft missions. As well as the usual statistical measures, the database includes a novel representation of large-scale variability, using empirical eigenfunctions derived from an analysis of the simulations, and small-scale variability using parameterizations of processes such as gravity wave propagation. The database may be used as a tool for mission planning, and also provides a valuable resource for scientific studies of the Martian atmosphere. Results from such analyses are presented here. The database is being updated as new observations become available and the models are improved. A version may be sampled at http://www.lmd.jussieu.fr/mars.html.

DRAMATIC SEASONAL CHANGE ON TITAN OBSERVED BY HST WFPC-2

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We have observed Titan using the Hubble Space Telescope Planetary Camera 2 in 1994, 1995 and 1997. This provides us with an unequalled dataset of imaging using the same instrument and the same filters (at 336, 439, 549, 588, 619, 673 and 889nm) over seasonal timescales. The North-South asymmetry in albedo was at its maximum in 1994-1995 and was expected to decline somewhat (by 30% or so) by late 1997. Remarkably, we find that the drop in asymmetry has been substantially faster, and at some wavelengths the asymmetry has reversed, which was not expected until 2002. We also note a pronounced drop in the limb-darkening coefficient at most wavelengths. These results suggest dramatic changes in the haze optical properties as a function of latitude, over timescales much shorter than one season, and we challenge modellers to suggest likely mechanisms. The results also caution against the use of globally- and temporally- averaged haze models to recover surface albedos on Titan : the haze is non-uniform and highly dynamic.

NUMERICAL STUDY OF SPATIAL AND SEASONAL DISTRIBUTIONS OF TRACE GASES IN THE MARTIAN MIDDLE AND LOWER ATMOSPHERE

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The current chemical stability of the Martian CO_2 atmosphere against UV photolysis remains intriguing in many aspects. A mechanism was proposed by Parkinson and Hunten (*J. Atmos. Sci.*, **29**, 1380, 1972) invoking the oxidation of CO to CO_2 by OH catalysis. It appears today that hydrogen peroxide may be the key atmospheric trace constituent for the chemical regulation of H_2, O_2 and CO in the Martian atmosphere. Nevertheless, no detection of H_2O_2 or HO_2 has been ever done. Moreover, from infrared observations performed during the last Phobos 2 mission in 1988, Korablev *et al.* (*Planet. Space Sci.*, **41**, 441, 1993) proposed that two measured absorption bands be attributed to formaldehyde. In this framework, an updated version of our two-dimensional model (Moreau *et al.*, *J. Geophys. Res.*, **96**, 7933, 1991) has been used to calculate meridional, vertical and seasonal distributions of trace gases in the Martian atmosphere. Simulations have been constrained by millimeter observations of minor species (i.e. HO_2, H_2O_2, CH_2O, CH_3OH, CH_3COOH) we obtained with the IRAM 30-m telescope (Granada, Spain) as well as by a new upper limit of methane abundance published by Krasnopolski *et al.* (*BAAS*, **26**, 1124, 1994). Finally, we discuss the potential formation of organic compounds such as CH_2O.

A PRELIMINARY STUDY OF DUST ADVECTION ON MARS USING WINDS FROM THE OXFORD MARS GENERAL CIRCULATION MODEL

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The presence of dust on Mars has a very significant effect on its climate and meteorology. Dust heating affects thermal structure and hence pressure and wind fields. Because of this large impact, there is usually a very pronounced difference between a model simulation with, for example, a relatively dust free atmosphere, and one with a dust distribution typical of a great dust storm. Also, defining a dust distribution which is constant in time is unrealistic; variations in dust loading are a major cause of inter-annual variability in the Martian atmosphere. This study is preliminary to producing a full dust transport scheme, which will be run actively with a Martian GCM, (i.e., radiative feedback and dust sources and sinks will be involved). The preliminary model looks at two-dimensional advection on a spherical surface. The advection scheme used is Semi-Lagrangian, in which the value of the tracer - here the dust mixing ratio - is determined by looking upstream. The accuracy and mass conservation properties of the method will be discussed, and the results of advecting an initially passive dust distribution, using horizontal winds obtained from a version of the Oxford Mars GCM, will be presented.

THE MIXING HEIGHT OF THE MARTIAN BOUNDARY LAYER, MODEL PREDICTIONS.

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The key features of the Martian boundary layer allow us to assume that its role on the global-scale and meso-scale atmospheric flows in Mars are different from the one at the Earth. At first Mars has a complicated nonhomogeneous terrain making the formation of a shear driven turbulent boundary-layer easy during the night, and further, it makes boundary-layer nonhomogeneous in convective conditions. At second, all diagnostic evaluations of the Martian boundary layer height predict it not to be small in comparision of the tropospheric height. All above mentioned makes the mixing height a key parameter in the Mars atmosphere studies. In suggested presentation we discuss different prognostic models for Mars mixing height determination and predict its diunal evolution for Viking landing sites. In our mixing height model for Mars we assume that in the morning the mixing layer is nearly neutrally stratified. Hence the height of the shear driven turbulent boundary layer in the morning is used as the initial condition to solve prediction equations for the mixing height. The main model assumption in Mars mixing modeling is that development of an unstable boundary layer is governed by same kind of similarity relations that are also applicable at the surface layer with new dimensionless characteristics connected with mixing height.

EFFECTS OF HAZE AND DYNAMICS COUPLING IN TITAN'S ATMOSPHERE

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A new model of atmospheric circulation in Titan that takes into account the effect of haze redistribution due to winds and latitudinal asymmetry in heating by visible light due to the asymmetric haze component is now working. This approach would permit to explain some observations not explained either by the previous GCM (hourdin et al.,1995) or by other studies such as the observed latitudinal temperature gradient, wind profile and the latitudinal haze structure related to the seasonnal albedo asymmety. We also investigate the effect of the aerosol structure (spherical or fractal) on the radiative transfer. The purpose of this work is to provide the clearest as possible view of the complex structure of the atmosphere, and to determine the important coupled processes that govern the dynamics, the thermal balance and the haze distribution.

THE DYNAMICS AND KINETIC THEORY OF THE NONTHERMAL ESCAPE OF H AND D FROM MARS AND VENUS BY ENERGETIC OXYGEN ATOMS

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Dissociative recombination of $O_2^+, O_2^+ + e \rightarrow O + O$, produces energetic oxygen atoms. These "hot" oxygen atoms can transfer their excess energy by collision with H and D. A detailed comparison of recently published OH, $X^2\Pi$, $^2\Sigma^-$, $^4\Pi$ and $^4\Sigma^-$ potentials is carried out. These potential functions are important in the accurate determination of O-H and O-D collision cross sections. The cross sections for O-H and O-D scattering is determined quantum mechanically. As an additional check of the bound $X^2\Pi$ potential the OH vibrational states are calculated and compared with measured values. A kinetic theory of the energization of H and D by energetic oxygen is developed and estimates of the enhanced nonthermal escape of H and D from Mars and Venus are calculated. The observed density distributions from satellite observations of Venus suggest a density profile characterized by two scale heights which is indicative of a hydrogen distribution characterized by two temperatures, one hot and one thermal. Detailed calculations of the H and D speed distribution functions, and the extent of the two temperature exospheres of these planets will be reported.

OXYGENATION OF THE TERRESTRIAL ATMOSPHERE: THE ROLE OF BIOLOGY

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There is no doubt that the release of molecular oxygen as a by-product of photosynthetic carbon fixation by plants and autotrophic microorganisms was the most important single process ever to make its impact on the terrestrial atmosphere. Since current photochemical models predict oxygen levels in the prebiological atmosphere within the range 10^{-8} to 10^{-14} PAL (Present Atmospheric Level), we may reasonably infer that life processes must be credited with the oxygenation of terrestrial near-surface environments (inclusive of the atmosphere), with free oxygen resulting from the reduction of CO_2 to the carbohydrate level by water in a light-powered reaction ($2H_2O^* + CO_2 \rightarrow CH_2O + H_2O + O_2^*$). Hence, the establishment of photosynthesis as the quantitatively most important biochemical process would provide a crucial temporal constraint for the first appearance of an oxygenated atmosphere. Various disparate lines of evidence suggest that photosynthetic carbon fixation is an ancient process, operated by microbial photoautotrophs as early as 3.5, if not 3.8 Gyr ago. Reduced (organic) carbon in the form of (partly graphitized) kerogen and related substances is a common constituent of sedimentary rocks since the beginning of the record 3.8 Gyr ago. Accordingly, the release of photosynthetic oxidation equivalents (O_2 in the case of water-splitting photosynthesis, SO_4^{2-} and S in the H_2S-based variants) must have commenced at the same time, i.e. extremely early in the Earth's history.

MODELLING OF LOCAL AND REGIONAL WEATHER PHENOMENA IN THE SAGAN MEMORIAL STATION (MARS PATHFINDER) LANDING AREA DURING ITS OPERATION

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The Mars Pathfinder landed in the Ares Vallis at 19.17°N, 33.21°W on 1997-07-04 (corresponding to late summer or $L_s \approx 143°$) and operated until Sep. 1997. The lander is located on a gentle large-scale slope which also exhibits surface albedo and thermal inertia gradients. We have modelled some boundary layer and mesoscale phenomena occurring in the Lander region using the Dep. of Meteorology / Univ. of Helsinki (DMUH) 1-D and 2-D Mars atmospheric models.
The 1-D model has high vertical resolution as well as a multi-layer surface and soil temperature prediction scheme; as a result the model reproduces the Pathfinder diurnal and vertical air temperature variations highly satisfactorily. The fitted temperature variations also provide estimates of the heat capacity and the thermal conductivity (thermal inertia) of the underlying soil.
The 2-D mesoscale model has been used to model explicitly the winds driven by the slope as well as by the surface albedo and soil thermal inertia gradients in the landing area.

CLOUD OPACITY AND WATER ABUNDANCE VARIATIONS IN JOVIAN HOT SPOTS FROM GALILEO/NIMS OBSERVATIONS

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The Near Infrared Mapping Spectrometer (spectral resolving power 200 at 5 μm) on board the Galileo spacecraft has observed many 5-micron hot spots in Jupiter's north equatorial belt at high spatial resolution (typically 300 km), obtaining many thousands of spectra of each observed region. From the 5-micron spectra (4.8-5.2 μm) the cloud opacity above 2 bar and the water relative humidity between 4 and 8 bar in the troposphere were derived, and for the first time maps of the spatial distribution of these parameters over hot spots were constructed. We observed that (1) the hot spots are dry areas (water relative humidity of typically several percent) with little cloud cover, in accord with results from previous analyses of Voyager IRIS data and the *in situ* measurements of the Galileo Entry Probe, (2) variations of a factor of 100 in the water relative humidity are found over hot spots, the values lying between 0.1 and 10 %, (3) outside hot spots, the water relative humidity does not attain saturation, but stays below about 50 % maximum, (4) cloud opacities are correlated to the continuum radiance at 5 μm, but the spatial distribution of water varies from one hot spot to another.

A FULLY STRATIFIED, PRIMITIVE EQUATION MODEL OF JUPITER'S ATMOSPHERE

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The dynamics of Jovian atmospheres have been extensively studied using one- or two-layer shallow water models. However, such models can make only limited progress towards understanding the vertical structure of the jets and eddies observed on Jupiter. Several attempts have been made in the last few years to develop fully 3-dimensional models of the upper jovian atmosphere, which overcome this limitation and allow the vertical structure to be explicitly resolved. A fully compressible, realistically stratified dynamical model of Jupiter's upper troposphere and stratosphere will be presented. This model, based on a terrestrial GCM (the UKMO Unified Model), solves the full primitive equations on the sphere, with simple physics appropriate to Jupiter. Results of high-resolution studies of a limited-area channel, based on a latitude band on Jupiter, are discussed. The system is initialised from a basic state which has both horizontal and vertical shear. Instabilities in the basic-state jets generate a range of Jupiter-like oval eddies, whose behaviour is strongly influenced by the jet structure. The results of these simulations will be presented and compared with observations from the Voyager and Galileo missions.

NICMOS OBSERVATIONS OF TITAN

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Titan has been observed from the Hubble Space Telescope in the near IR using the NICMOS instrument in methane bands and in the window regions between the bands. Both the leading and trailing faces of Titan have been observed allowing the large bright feature on the leading face to be analyzed in relation to the dark trailing face. Several features in the images are of interest. First, there is a low contrast radial ripple seen in the images, an unusual limb darkening profile that has implications for the vertical structure of the lower atmosphere. Second, surface features are clearly visible and they can be compared to previous observations both from groundbased and from HST images. Third, polarization of the disk has been measured for the first time from HST. The images are so new at the time of this abstract that analysis has not yet been done on these images; progress will be reported at the meeting.

THE METHANE ABSORPTION VARIATIONS ON JUPITER's DISK FROM DETAILED ZONAL CCD-SPECTROPHOTOMETRY IN 1997

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Near-zero jovicentric declination of the Earth in 1997 was favourable for detailed study of the methane absorption distribution on the disk of Jupiter using zonal spectrophotometry with 1-meter telescope and CCD-camera ST-6V. The images of the spectra were recorded at the slit of spectrograph oriented parallely to the equator and moved consistently from pole to pole with the step 1 arcsec. Thus four series, each of them included 44-46 zonal spectra, have been obtained in August 1997 as well as a number of the equator and central meridian spectra. All spectra were divided on the spectrum of Saturn's ring to exclude nonmonotonic spectral sensitivity of the CCD-matrix. The central depths of the methane absorption bands at the wavelengths 619, 725, 798, and 887 nm have been determined for approximately 3200 points on Jupiter's disk. The maps of the methane absorption variations on the disk were presented at isoline, semitone and 3-D view. The lower methane absorption may be seen on Jupiter's equatorial belt and near the poles where bright polar hoods are seen on the images restored from zonal spectra at 725 and 887 nm. The Great Red Spot looks on these images as light detail. Most zones have very small center-to-limb variations of the band depths excluding high latitudes where the decrease of absorption towards limb is expressed more strongly. Some differences are in the band 798 nm overlaying with the ammonia band 791 nm. Preliminary analysis of these results have shown also that the moderate and strong absorption bands variations have clearly expressed zonal character but weak absorption band shows chaotic variations on the disk. Considering these data as an example of the optical sounding of the Jovian atmosphere we could conclude that deeper layers are more affected to local convective-turbulent atmospheric motions than the layers near upper boundary of the visible clouds where zonal currents are more effective.

NATURE OF GREENHOUSE EFFECT IN THE EARTH ATMOSPHERE

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It was shown that the average temperature at any level of the dense planet troposphere (with pressures more than 200 mbar) is one -valued determined by the solar radiation intensity, atmospheric pressure , heat capacity and humidity of the troposphere. Fined regularity allowed to carry out series of the prognosis calculations. So, by a mental substitution of the nitrogen - oxygen Earth atmosphere on the carbonic - acid one but with the same pressure equal to 1 atm., the average surface temperature decreases (not increases) approximately by 5° C . From here it is clear that the atmosphere saturation by carbonic- acid gas in spite of the infrared radiation absorption by this gas (with other conditions being equal) always causes not increase but only decrease and greenhouse effect, and average surface planet temperature.

The Earth climate reaction on the anthropogenous emission in atmosphere of the carbonic - acid gas is determined by two factors : firstly, by the atmosphere pressure increase; secondly, by the adiabat index value decrease of atmospheric gases mixture. These two factors change the troposphere temperature regime in contrary directions and in a result the troposphere temperature regime practically does not change. Moreover , the carbonic - acid gas concentration increase may be useful factor , raising the agriculture effectivity and icreasing restoration velocity of the cleared woods.

NUMERICAL SIMULATIONS OF ZONAL FLOWS FORCED BY DEFORMATIONAL LONG-WAVE INSTABILITY

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The effect of forcing of large-scale flows by deformational long-wave instability appears in a first order due to deformation of the upper free surface of the rapidly rotating layer heated from below. So the linear problem gives infinite solutions and it is necessary to take into account the next terms in the expansion of negative diffusion coefficient in the deformation of the upper stress-free surface. In this case it is possible to obtain stationary mean zonal flows with shear in latitude. Stationary zonal flows can have different spatial periods in latitude. So different situation which are realized in the atmospheres of outer planets can be described by appropriate choice of negative diffusion coefficients.

Intrinsic Martian magnetic field effect on Mars' atmospheric evolution

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The Mars Global Surveyor mission has shown that Mars possesses a complex planetary magnetic field resulting from remanent crustal magnetism. This magnetic field influences atmospheric escape via sputtering and pick-up loss processes at present. An ancient stronger magnetic field, responsible for the remanent crustal magnetism, would reduce these processes on early Mars to negligible amounts. Here we revise previous estimates of non-thermal atmospheric escape from Mars, update the models of atmospheric evolution and estimate the magnitude of the surface sink for oxygen resulting from H_2O.

AN EXTREMUM PRINCIPLE FOR LINEARISED VERTICAL STRUCTURE EQUATIONS FOR PLANETARY ATMOSPHERE

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It will be shown that the standard vertical structure equation (applicable to any planetary atmosphere) arises eg from the linearised, adiabatic quasi-geostrophic vorticity equation (where streamfunction is assumed to be vertically separable) is an immediate consequence of an extremum principle which minimises the functional of available potential energy in the vertical direction. Such an extremum principle would seem to describe the natural tendency of an atmosphere to seek states of minimum available potential energy through the release of kinetic energy in the form eg of baroclinic transient eddies. This principle is illustrated with reference to a climate simulation using a simplified General Circulation Model of the Martian atmosphere (in which the meteorological primitive equations are solved on a sphere with simplified physical parameters). The results imply that the Martian atmosphere places the majority of the available potential energy in the leading order minimum available potential energy modes. The results from this Mars GCM will be presented and discussed in terms of the dominant physical processes responsible for the generation and release of available potential energy in the Martian atmosphere.

PS4 Planetary magnetospheres and ionospheres

Convener: Prangé, R.
Co-Conveners: Dougherty, M.K.; Sauer, K.

IMPROVED THEORY OF PLASMA MASER IN THE JUPITER RADIATION BELTS

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General theory for plasma maser in the Jupiter radiation belts is developed. Real channels of particle sources and losses are taken into account. An influence of relativistic particle energies, small loss cone and fast magnetospheric rotation is considered. Background plasma disc specifies narrow range of effective interaction of electromagnetic waves and energetic particles. This circumstance makes theoretical model easier as compared with the past ones. For different relations between characteristic system eigen times effective forms for definition interaction of waves and particles is chosen.
The results are important for quantitative analysis of Voyagers and Ulysses date set. The improved theory describes both average wave and particle flux characteristics, its time variation and fine structure.

A COUPLED MODEL OF THE IONOSPHERE AND THE UPPER ATMOSPHERE OF TITAN

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The Lara *et al.* model of Titan's atmosphere is coupled with the ionospheric model that includes photoionization, photoelectron and magnetospheric electron sources, recombination losses as well as bi- and tre-molecular ion-neutral reactions taken from the data base compiled by Anicich and McEwan (1997). Although the electron density profile is similar to that obtained by Keller *et al.* (1992), with the maximum plasma density of about 5000 cm^{-3} at 1050 km, the altitude profiles of several components, like $C_2H_5^+, CH_5^+, CH_3^+$, are different. Densities of most of neutral atmospheric constituents are insensitive to the coupling with the ionosphere, but for some components, e.g. C_3H_8, significant changes, resulting from ion-neutral reactions, are observed at higher altitudes (> 1200 km). Several solutions of the atmosphere-ionosphere model, differing in the input parameters used (source terms, reaction rates), will be presented.

MAGNETIC HOLES AND UPSIDE-DOWN WAVES IN CONNECTION WITH JOVIAN MIRROR MODE WAVES

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During the outbound Ulysses flyby of Jupiter, the longest train of mirror mode waves ever observed was recorded. Towards the end of this train, reversed mirror mode or "upside-down" waves are observed, consisting of enhancements in the magnetic field rather than depressions. A transverse wave component, believed to be ion cyclotron waves, is found to be superimposed on top of the compressional mirror mode component. Several hours after these upside-down waves, three trains of magnetic holes such as those reported by Winterhalter et al., 1994, in the solar wind are observed. These are believed to be remnants of mirror mode waves.

3D MULTISCALE MASS LOADED MHD SIMULATIONS OF THE SOLAR WIND INTERACTION WITH VENUS AND MARS

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Various ionization processes take place in the solar wind interaction region around Venus and Mars. The combined effect of these processes is mass addition to and momentum loss by the plasma flow in the vicinity of the planet. We examine the contributions of the effects due to the ionization of planetary thermal and hot oxygen and hydrogen by solar radiation, electron impact and charge exchange with the solar wind; we include the appropriate collision terms in the continuity, momentum and energy equations. Our three-dimensional, multiscale, single fluid, ideal magnetohydrodynamic [MHD] model works on an adaptively refined unstructured grid, which gives sufficiently high resolution in all areas of interest, without requiring to reduce the size of the simulated volume. Thus, it is possible to examine mass loading effects in a continuous region from outside the bow shock to the magnetotail. We used our model to study the mass loading effects on the solar wind interaction with Venus and Mars. We compared our model results with magnetic field observations from the Pioneer Venus Orbiter instrument and observations from the Phobos-2 mission.

DYNAMICS AND SPATIAL DISTRIBUTION OF SATURN'S E RING PARTICLES

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The tenuous E ring of Saturn, formed by micrometer-sized particles produced presumably by the icy moon Enceladus, furnishes an excellent example of dust-magnitosphere interactions. The ring's grains move through the ambient plasma that makes their dynamics and spatial distribution dependendent on the collected charges and parameters of the plasma environment. Therefore, the magnetospheric parameters are reflected in the E ring features and may be constrained by a comparison between the models and observational data. A special interest in the E ring studies is connected with the Cassini spacecraft which is planned to make many crossings of the Saturn's equatorial plane and will obtain a large array of new observational data.
We have investigated the dynamics of Saturn's E ring dust particles, taking into account perturbations due to the solar radiation pressure, the planetary oblateness, the Lorentz force arising from the three zonal harmonics of planet's magnetic potential, and the plasma drag. On the base of numerical integrations of equations of motion of a large number of individual grains, a model of the overall E ring is constructed. Optical depth profiles are computed and compared to the observational data. It is shown that the model constructed is in better agreement with the observations than previous ones.

MULTIPLE SHOCKS NEAR MARS

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Mars gives us an example of the magnetosheath, in which the interaction of the solar wind with planetary plasma of heavy ions results in generation of strong nonlinear bi-ion MHD waves. The 1D hybrid and 2D bi-ion MHD simulations of the plasma flow around ion 'cloud' were performed to study dynamics of these waves. It is shown that differential motion of protons and heavy ions leads to a bunching of plasma flow. Bunching arises due to resonant interaction between waves excited by heavy ion beam and slow waves in the heavy ion flow. Waves grow, steepen and evolve to shocks. Application of these results to Mars is given.

THE FORESHOCK BOUNDARY AT MARS

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Multi-instrument analysis of measurements near the boundary of the martian foreshock reveals some new features as compared with other planetary foreshocks. Electric emissions at frequencies around 100Hz and ULF fluctuations often preceed to electron plasma waves which characterize the electron foreshock. A bending of the magnetic field is also observed upstream of the tangent line. Main signatures of the field variations is a change of sign of the ΔB-perturbations across the tangent line, which borders foreshock and the undisturbed solar wind, and a bipolar structure centered relative to the plane which is normal to the tangent surface and intersects the bow shock at the tangent point. The bending is accompanied by distinct variations of the solar wind velocity which replicate the field perturbations. Amplitudes of perturbations follow Walen relation. Observations suggest the presence of Alfven waves near the foreshock boundary.

THE ASYMMETRIC BRIGHTNESS OF JUPITER'S RADIATION BELTS, AND VARIATIONS WITH D_E

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We present Australia Telescope Compact Array (ATCA) observations of Jupiter of July 1995, July 1996, and November 1997, at 13 and 22 cm, and Very Large Array (VLA) observations of May 1997 at 21 cm. From a series of high resolution, 2-D images the peak brightness above the east and west limbs is derived at different rotational phases. In 1995 the jovicentric declination of Earth, D_E, was $-2.9°$, in 1996 it was $-1.7°$ and in 1997 it was essentially $0°$. The longitude λ_{III} of the "bright region" moved from $210°$ in 1995 to $190°$ in 1997. The ratio of east-to-west limb brightness as a function of λ_{III} ranged from 0.8 to 1.3 in 1995, and the range decreased steadily to 0 to 1.1 in 1997. The asymmetries and their changes with rotation of Jupiter are the result of the warped magnetic equator, and thus are simply explained by using a magnetic field model giving the magnetic declination D_{mag} in the radiation belts; the new hexadecapole model (Connerney 1997) is better than the O6. When $D_E = 0°$ the east and west limb brightnesses should be the same for each λ_{III}, i.e. the E/W asymmetry should disappear. The observations of May 1997, when D_E was $-0.04°$, show indeed that there was no E/W asymmetry, except at $\lambda_{III} = 190°$ where the east limb was brighter than the west one by about 10%; this is not yet explained.

CENTRIFUGAL INSTABILITY IN ROTATING PLASMA DISKS

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The Jovian magnetosphere contains an extended plasma disk, which is entrained by the rapid planetary rotation. The plasma, originating primarily from the satellite Io, is transported outward to the remote regions where it escapes to the interplanetary medium. This plasma transport is generally believed to result from the centrifugal instability, i.e., a Rayleigh-Taylor type instability in which the centrifugal force plays the role of gravity. However, the properties of the unstable motions as well as the precise form of the stability criterion are still a matter of controversy. Most studies to date make the assumption that magnetic flux tubes undergo either pure interchange motions which leave the background magnetic field totally unchanged, or more general interchange motions which allow for changes in magnetic field strength while preserving the field direction.
We reexamine the problem of the centrifugal instability, trying to determine in a self-consistent manner the characteristics of the unstable motions. In particular, we show that a displaced flux tube adjusts its total pressure to its new surroundings and that this adjustment usually entails a violation of the interchange hypothesis. We derive a general dispersion relation, which includes the effects of the centrifugal force, plasma pressure, field line curvature, coupling with the ionosphere, and plasma motions along field lines.

MODELING THE MAGNETOSPHERES OF JUPITER AND SATURN WITH A 3D AMR MHD MODEL

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The Michigan Global Magnetosphere Model is a recently developed three-dimensional solution adaptive code which solves the equations of ideal magnetohydrodynamics with our MAUS-MHD method (Multiscale Adaptive Upwind Scheme for MHD). The code is implemented for massively parallel computers and runs considerably faster than real time on a Cray T3E with 512 processors. The model is applied to simulations of the magnetospheres of rapidly rotating giant planets. The simulation takes into account the distributed plasma source due to the presence of satellite tori and it models the global structures of the magnetosphere for various IMF conditions.

Angular Momentum of Jovian Dust Stream Particles

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Impacts of dust stream particles were observed during all passages of the Galileo spacecraft through the jovian system inside 100 jovian radii. Distinct start and stop times of the dust streams were recognized as well as times in between when the impact direction changed by 180 deg.. These three times are compatible with particles entering and exiting the field-of-view of the dust detector and those arriving along the spacecraft spin axis. It is assumed that particles on the same mean trajectory cause this behavior. Model calculation of electromagnetically accelerated dust grains of different sizes, initial speeds, and charge states have been performed for different places of particle release in the jovian system. It is found that only trajectories of particles of high angular momentum can explain the observations. Only trajectories of 5 to 10 nm-sized particles that have been generated outside about 5 Jupiter radii distance from Jupiter match the observed impact directions.

RESULTS OF JOVIAN DUST STREAM ANALYSIS

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Since the arrival of Galileo at Jupiter 1995, much new information on jovian system dust was gathered. Most probably three populations were found: dust on bound orbits, dust sputtered from the galilean moons and the known stream dust particles.

Analysis, especially for the stream dust, is depending strongly on modelling. The here used model is in priciple capable to describe all populations. However, the stream particles keep most interesting for modeling. These nanometer-sized grains are charged within the jovian plasma environment and swirled away by Jupiter's strong magnetic field. Calculations are done with respect to charging processes and magnetic and gravity fields. Recent modeling is now able to describe correctly the direction from which these particles are arriving at Galileo spacecraft and to show the special 5- or 10 hour periods coming from the rotation of jovian plasma and magnetic fields in the calculated impact rates. Preliminary conclusions are pointing to a stream particle source at or near the orbit of Jupiter's moon Io.

The latest calculation results and interpretations will be presented in the conference.

THE STRUCTURE OF JUPITER'S MAGNETOSPHERE: NEW OBSERVATIONS FROM GALILEO

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With the successful conclusion of Galileo's prime mission, a large data set of field and particle measurements in the dawn to mid-night sector of Jupiter's magnetosphere has become available. The Real Time Science (RTS) mode of Galileo provides MAG data at a resolution of 24 sec. or better and is ideally suited for the studies of the structure of Jupiter's magnetosphere. Approximately 5000 hours of MAG data are now available in this mode. In this report we will present a summary of new results from the RTS survey. New observations show that in the middle magnetosphere (radial distance between 40 and $90R_J$), the field strength is smaller in the midnight sector than in the dawn sector. This observation suggests that the magnetotail influence may begin as close as $40R_J$ from Jupiter. The observations also show that the field line sweep-back is larger in the dawn magnetosphere compared to its value in the midnight sector. Mechanisms that cause such differences will be discussed. Observations of the current sheet structure show that the current sheet crossing times are less delayed in the midnight sector and its hinging has a different functional form than deduced from the dawnside observations. Finally, we show that temporal variations on time scales of days are probably caused by changes in the solar wind forcing.

GALILEAN MOONS OF JUPITER: MAGNETOSPHERES AND WAKES

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During its prime mission, Galileo acquired fields and particles data close to each of the four Galilean moons of Jupiter. Here we shall summarize key aspects of the interaction between the moons and the magnetic field and plasma of Jupiter's magnetosphere. The interactions are partially cometary in nature and partially governed by the internal electrical and magnetic properties of the moons. As an example of the interaction with a magnetized moon, we will describe Ganymede's remarkable miniature magnetosphere, topologically analogous to a planetary magnetosphere but lacking a bow shock, a plasmasheet, and a plasmasphere. Energetic electrons can generate a ring current. We will then show how the cometary interaction contributes to the signatures of the downstream wakes of Ganymede, Europa, and Io.

THE IONOSPHERES OF THE GALILEAN SATELLITES OF JUPITER

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The Galileo spacecraft has provided multiple opportunities for radio occultation investigations of the Galilean satellites of Jupiter: Io, Europa, Ganymede, and Callisto. There have been 12 measurements of the ionosphere of Io. They present an ionosphere controlled by its interaction with the magnetosphere of Jupiter, with a maximum electron density of 20,000 to 60,000 60,000 el./cc on the "upstream" side, with or no ionization above 200 km , and a maximum density of 60,000 to 100,000 el./cc on the "downstream" side , with ionization extending to at least 3,000 km. On Europa, evidence was found of a much more tenuous ionosphere, with a peak density of 5,000 to 14,000 el/cc and a greater vertical extent in the downstream direction. On Ganymede, six radio occultation measurements provided inconclusive results in four instances, with only two upstream measurements suggesting an ionosphere with a maximum density of about 5,000 el./cc near the surface. This could be due to its own magnetosphere, which may be shielding its surface from Jupiter's magnetospheric plasma. The single occultation by Callisto provided only two profiles , remarkably similar to each other, with 2,000 el./cc maximum density.

COMPARATIVE MHD SIMULATIONS OF THE INTERACTION OF THE GALILEAN SATELLITES WITH THE JOVIAN MAGNETOSPHERE

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The Galileo mission to the Jovian system has revealed a lot of new facetts of the interaction of the four Galilean satellites with the magnetosphere: Ganymede has an intrinsic magnetic field, whereas the three other satellites, in particular Io, are plasma sources with different source regions and production rates. An open question is whether the strong decrease in the magnetic field observed in Io's wake can be explained by mass loading effects or an intrinsic magnetic field.

3D resistive MHD simultions of the interaction of all four satellites with the Jovian magnetosphere are performed in a cylindrical coordinate system with Jupiter at the origin. In the case of Ganymede the magnetic field configuration is the superposition of the dipole field of Jupiter and Ganymede. In the other cases the magnetic field Jupiter's dipole field, but individual plasma source terms are added to the MHD equations. The goal of the simulations is to investigate the influence of mass loading on the evolving current system and flow pattern on the one hand and to look for new features caused by taking into account Ganymed's dipole field.

THE ETHEREAL DUST ENVELOPES OF THE MARTIAN MOONS

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We consider the impact ejecta from Phobos and Deimos to study the statistics, spatial distributions, and volume densities of the dust debris in the vicinities of the moons. Apart from the graviational forces, we take into account solar radiation pressure, which makes our model valid for micrometer-sized particles. The radiation pressure modifies the shapes of the circumsatellite dust clouds, displacing them in the anti-solar direction; the effect is much larger for the Deimos ejecta. Another radiation pressure effect is the decrease of the mean escape velocity of the Deimos ejecta from 5.5 m sec^{-1} for 10–100 μm-sized grains to 4.5 m sec^{-1} for 1 μm-sized ones. We also explore the time variations in the dust clouds caused by individual impacts of larger meteorites. These variations are shown to be relatively unimportant for the micrometer-sized dust, but may be pronounced for centimeter-sized debris.

DUST NEAR THE BOUNDARY OF SATURNIAN MAGNETOSPHERE: THE ORIGIN, EVOLUTION, AND FATES OF EJECTA FROM HYPERION

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The surface of Hyperion, a small icy satellite of Saturn, is exposed to hypervelocity impacts of two classes of projectiles — interplanetary grains and dust particles coming from the outermost moon Phoebe. As a result, the surface material of Hyperion is continuously ejected to the planetocentric space. The ejected grains experience a large array of perturbing forces — Titan's gravity, radiation pressure, and the plasma drag force, the latter being quite complex as the Hyperion orbit is close to the boundary of Saturn's magnetosphere. Unlike the motion of Hyperion, stabilized by a strong 4:3 mean motion resonance with Titan, the orbits of Hyperion's ejecta are liberated from the resonance and experience multiple close approaches to Titan. Using numerical integrations of a large number of grains' trajectories, we derive a spatial distribution of dust in the Hyperion-Titan system and find out the eventual fates of the debris. Most of the grains larger than $\sim 5\mu$m in size finally collide with Titan, whereas smaller particles typically hit Saturn. Our estimates of the dust influx to Titan show that the upper limit of the income rate of the Hyperion particles may exceed the direct influx of IDPs by two orders of magnitude. The influx of icy (H_2O) particles from Hyperion is suggested as a possible explanation of the observed abundance of CO_2 molecules in Titan's atmosphere.

GALILEO OBSERVATIONS OF DUST PARTICLES EJECTED FROM JUPITERS GALILEAN SATELLITES

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The Dust Detector System (DDS) onboard the Galileo spacecraft measures sub-micrometer and micrometer sized dust particles in the Jovian system. Enhanced dust impact rates have been detected within several minutes around the closest approaches of the spacecraft to the three Galilean satellites Callisto, Ganymede and Europa. The impact directions and velocities of these particles are compatible with particles originating from the satellites themselves. Their sizes are in the range 0.3 to 1μm. We interpret these particles as secondary ejecta particles kicked up by impacts of micrometeoroids onto the surfaces of the satellites. Such an ejection process of secondary particles has been suggested as being responsible for maintaining both the Jovian ring and Saturn's E ring. The measured impact rates indicate that each satellite is surrounded by a dust cloud with increasing density towards the satellite. In the case of Ganymede the extension of the cloud is only a few satellite radii.

ENERGETIC PARTICLES IN THE JOVIAN MAGNETOSPHERE: RESULTS FROM THE ENERGETIC PARTICLES DETECTOR (EPD) ON BOARD GALILEO

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During its prime mission Galileo spent two years inside the Jovian magnetosphere. It was possible for the first time to monitor the Jovian magnetosphere for such an extended time period. The data coverage ranges from 10 Jovian radii (R_J) at perijove in the post noon sector and 150 R_J in the Jovian magnetotail near midnight. Ion (22 keV-55 MeV) and electron (15-884 keV) measurements from the Energetic Particles Detector (EPD) were used to investigate the overall morphology of the Jovian magnetosphere. We observed a pronounced dawn-dusk asymmetry in the inner magnetosphere with higher particle intensities in the dusk sector relative to the dawn sector at comparable distances. These enhancements were associated with particle anisotropies in radial direction away from the corotation direction. In addition EPD observed a change in the ion energy spectra between 20 and 25 R_J related to a transition between a dipole-like magnetic field topology and the equatorial current sheet beyond that distance. We will present a detailed study of the Jovian plasma sheet as a function of local time and distance.

PLANETARY IONS IN THE MARTIAN TAIL

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Based on a recent model of the martian atmosphere/exosphere and a model of the magnetic field and solar wind flow around Mars, the distribution of different planetary ion species in the tail is modeled. Three main regions are identified: 1) 'clouds' of pickup ions with mass/charge separation travel along cycloidal trajectories, 2) plasma mantle, 3) plasma sheet. Energy of ions in these regions is analysed and compared with observations. Escape rates of ions of different species are estimated.

THE IONOSPHERE OF TITAN: IDEAL DIURNAL AND NOCTURNAL CASES

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We have solved a stationary Boltzmann transport equation to describe the ionosphere of Titan in two simple cases.
The first one deals with the satellite being outside the Kronian magnetosphere on the dayside of Saturn. We show the effect of the photoionization and the secondary ion production. From these results, we deduce the intensity of different N_2 emission lines, that are compared to the Voyager 1 measurements. We estimate the electron density from a full chemical code. This electron density is then compared to the one computed from a simple recombination model. In the second case, the satellite is inside the Kronian magnetosphere. We show the effect of the ionization due to electron precipitations at night, above the polar regions. The input electron flux is measured by the Voyager probes, gathered from several instruments onboard. A model of the mean electron flux precipitating on Titan is proposed. The photoelectron production above the pole is compared to the effect of the Kronian electron precipitations.

A STUDY OF THE LARGE SCALE DYNAMICS OF THE JOVIAN MAGNETOSPHERE USING THE GALILEO PLASMA WAVE EXPERIMENT

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Using radio wave observations performed by the Galileo PWS experiment, we show that large scale energetic phenomena recurrently occur in the Jovian magnetosphere with a periodicity of 50 to 80 hours. Their onsets are indicated by sudden detections of bursts of kilometric radiations (b-KOM). They are followed by intensifications of the auroral radio emissions (DAM and HOM) and also correspond to important reorganizations of the sources of the n-KOM, a specific emission coming from the outer regions of the Io torus. Moreover, Galileo, located at more than 60 Rj from Jupiter, observes important modifications in the structure of the magnetodisc. Regions of extremely rarefied plasma having a limited longitudinal extension are crassed. These perturbation are observed for 10 to 20 hours and are followed by thickenings of the magnetodisc. These energetic events play an important role in the control of the different jovian radio emissions and present obvious analogies with the geomagnetic substorms. They should be the consequences of explosive releases of energy in the jovian magnetosphere.

OBSERVATIONS OF H_2 $\lambda = 2.121\mu$ AND H_3^+ $\lambda = 2.093\mu$ EMISSION IN JUPITER'S NORTH POLAR CAP SHORTLY AFTER THE IMPACT OF COMET SL9

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As part of the international campaign to observe the impacts of the fragments of comet Shoemaker-Levy 9 on Jupiter from the ESO observatory on La Silla we obtained infrared (K-band) images of Jupiter with the IRAC2b camera attached to the 2.2m telescope between July 22 and 24, 1994. The images were taken through a tunable Fabry-Perot-interferometer with spectral resolving power of 1400. The lines $\lambda = 2.093\mu$m (H_3^+) and $\lambda = 2.121\mu$m (H_2 quadrupole transition) and a continuum at $\lambda = 2.108\mu$m were observed. The observations cover almost a full rotation of Jupiter. The observing method necessitates evaluation of the difference between on-line and continuum emission. Therefore the ability of the method to detect line emission is strongly dependent on the intensity of background continuum. Because of the strong continuum present at the impact sites no line emission directly associated with the impacts could be observed, but we find line emission in an auroral arc close to the $L = 30$ shell around $\lambda_{III} = 150°$. Its intensity appears enhanced as compared with previous spectral measurements. This is probably caused by the SL9 impacts.

FAR UV JUPITER'S AURORAS IMAGES IN HIGH SPATIAL RESOLUTION WITH FAINT OBJECT CAMERA ON POST COSTAR HUBBLE SPACE TELESCOPE

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We present here a set of 8 far UV images of Jupiter's aurorae taken on 25 june 1994 with the Faint Object Camera (FOC) on board the Hubble Space Telescope (HST) after correction of its spherical aberration. A fast wavelet transform (FWT) processing has been used to enhance auroral structures. The emission were faint on that particular day, but all structures are identified: main oval, diffuse polar cap emission and narrow concentric arcs are observed in the north hemisphere. We will discuss the differences betwen our observations and the magnetic field model and we will compare this set of images with images obtained a few months later.

KINETIC CHARACTERISTICS OF THE SOLAR WIND INTERACTION WITH MARS

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The measurements made by the MAG/ER experiment onboard Mars Global Surveyor has provided a huge amount of new informations on the magnetic topology of Mars, proving definitively that the planet does not possess a measurable global dipolar magnetic moment. These results also indicate that the solar wind interaction with the planet produces a magnetic environment that is unique among the planets of the solar system. This interaction occurs on spatial scales where the ion gyroradii are larger than the subsolar region thickness and comparable to the planet radius. This strongly suggests that the ion kinetic effects play a significant role. These include the wave-like behavior of the bow shock region and the observed asymetry of the magnetic structure, particularly on the magnetic pileup. We present a correlative analysis of the magnetic field and electron plasma data and discuss the results in the light of recent modeling and simulation efforts.

INFLUENCE ON THE EARTH'S MAGNETOSPHERE OF A DUST RELATED TO COSMIC BODIES

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The influence on the Earth's magnetosphere of a dust related to cosmic bodies which can appear in the vicinity of the Earth is studied. Two possibilities for the appearance of the dust are considered: 1) cosmic bodies entering the Earth's magnetosphere are embedded in a dust cloud; 2) dust grains appear as a result of condensation after destruction of a cosmic body due to an explosion which pursues the goals to prevent "asteroid hazard". The process of dust particles charging in the magnetosphere is taken into account. It is shown that the presence of charged dust particles can result in formation of a current system in the magnetosphere. Its possible consequences for the Earth's environment are studied. The conditions on the parameters of the explosion in the problem of the prevention of "asteroid hazard" (when this explosion consequences for the Earth's environment are not dangerous and, in particular, one can neglect a violation of the magnetosphere structure as a result of this explosion) are found. A scheme of an active geophysical experiment which models the interaction of a dust related to cosmic bodies with the Earth's magnetosphere is proposed.

SWS SPECTRAL SCANS OF ASTEROID 4 VESTA

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The 2.4-45.2μm spectral properties of the Vesta-class prototype (4 Vesta) are being explored at high resolution ($\lambda/\Delta\lambda = 1000$-3000) with the ISO-SWS. Several observations have been obtained, including short integrations in selected passbands over its well-defined rotation period, showing spectral and photometric variability. The spectral signature in the 30-45μm region is examined for its expected basalt achondrite composition as a link to the howardite, eucrite, and diogenite (HED) meteorites. From such a link, the grain size distribution of the Vesta regolith can be estimated by comparison to reflectance spectra of powders from [presumedly spawned] HED meteorites, as done in the 0.3-2.6μm region by Hiroi, Peters, & Takeda (1994, Meteoritics, 29, 394).

A STUDY OF THE DYNAMICS OF AURORAL PROCESSES ON JUPITER. CORRELATION WITH GALILEO MEASUREMENTS.

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During the period 08/17 - 09/25 1996, FUV auroral spectra of Jupiter were acquired on a quasi continuous basis as part of the last IUE Key Project. This campaign was coordinated with Galileo measurements. The variability of the flux in the H_2 bands (1560-1620 Å) is quantified in each hemisphere by an "auroral activity index", calculated every 5 to 10 hours. The activity indexes in both hemispheres are generally similar and indicate a strong interhemispheric conjugacy. We identify variability on three different scales: small variations of 10-20% are observed on short time scales (~ a few hours), variations by a factor of 2 to 4 occur on scales of 5-10 days, and a long term trend is observed on a scale which exceeds the 6 weeks of observations. The medium scale variations are amazingly well correlated with the state (quiet or disturbed) of the magnetic field measured by the magnetometer on board Galileo, although distances from ~ 15 to ~ 115 R_J and all local times were sampled during that time. This indicates temporal, rather than spatial, variations of the magnetic field, and suggests that some dynamical process, yet to be identified, affects the magnetosphere as a whole. Correlations have also been found with the intensity of the auroral radio waves measured by the Galileo PWS experiment .

IO-CONTROLLED DECAMETER ARCS AND IO-JUPITER INTERACTION

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The sweeping of the satellite Io by Jupiter's magnetic field results in an electrodynamic circuit, approximately fixed in Io's frame, revealed by UV and IR spots at the footprints of Io's flux tube (IFT) as well as prominent decameter radio arcs. We analyze the frequency-time shape of nine of these "Io-arcs", detected over their full frequency extent in joint Nancay and Wind data, and corresponding to four observation geometries (A,B,C and D). We compute the radio beaming angle as a function of frequency and lag of the radio-emitting flux tube(s) relative to the IFT. No assumption is made on the radio source location or beaming. We find northern (resp. southern) sources for A and B arcs (resp. C and D). The shape of all Io-arcs is consistent with origin from a single flux tube (in Io's frame), shifted by 10! (in the south) to 20! (north) with respect to the IFT. This lag must be accumulated before Io's magnetic perturbation reaches high latitudes. Radio emission is beamed in a hollow cone of average aperture 75! and thickness 1!. Arc shapes are fully determined by the geometry of observation. Radio fringes preceding the main Io-B arcs are well explained by multiple reflections of the magnetic perturbation between Jupiter's ionosphere and Io's torus. The weak trailing part of Io-B arcs may be accounted for through double-beaming of the radio emission or a frequency- dependent lag of the corresponding radio source. The latter explanation suggests an emission scenario in which electron acceleration "leaks" from the magnetic perturbation on its way to Jupiter. Magnetic field models are compared and evaluated in the analysis.

A DETAILED MAPPING OF THE MAGNETOPAUSE SURFACE OF A GLOBAL MODEL OF MERCURY'S MAGNETOSPHERE

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A fitting of the Mercury magnetometer data to a magnetosphere model scaled and adapted from an earth-based model has been published in Planetary and Space Science (January, 1997). The model is comprised of a self-consistent sum of contributions representing (i) a tilted, offset planetary dipole to represent the intrinsic planetary contribution, (ii) a scaled magnetotail contribution, and (iii) a separately scaled contribution representing the effect of the solar wind interaction. The vector sum of the three contributions within the model magnetopause represents the model magnetospheric field. The field is mathematically defined outside the magnetpause even though there is no associated physical significance. To aid in the use of the Mercury field model for future mission planning purposes, a mapping of the magnetopause was done and is presented as a 5° by 5° grid representation of $R(\theta, \phi)$, where θ is a co-latitude and ϕ is a longitude. For any particular (θ,ϕ) a maximum distance R was determined such that the field line passing through that location would have at least one footprint on the planet and, if lacking a second footprint, would be a well-defined tail line. Each location on the model's magnetopause has passing through it a field line with at least one footprint in the vicinity of a cusp.

THE SOLAR WIND-MARS INTERACTION FROM THE MARS GLOBAL SURVEYOR SPACECRAFT MEASUREMENTS

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The Mars Global Surveyor (MGS) spacecraft is in an elliptical orbit around Mars since September 11, 1997. At the time of the EGS meeting more than 100 orbit results, with a very low altitude periapsis (150 Km or less) to cover ionopause traversals and an apoapsis large enough to cover all the interaction from the upstream regions of the shock , the shock and the pile-up magnetic field region, will be available. The MAG/ER instrument on board MGS includes magnetic field and electron distribution measurements. The first results show that the ionized environment of Mars is higly assymetric and looks, from many points of view, both like the solar wind-active comet interaction and the solar-wind-Venus interaction. This is linked to the absence of an intrinsic magnetic field of the planet Mars as it is now well proven from the results of our instrument. However the martian ionized environment has its own peculiar features, some of them being related to localized strong crustal remanent magnetic fields. An overview of these new and extremely important results on the ionized martian environment will be presented.

LOW FREQUENCY TURBULENCE AT THE MARTIAN BOW SHOCK: PHOBOS-2 OBSERVATIONS.

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Magnetic and electric field measurements obtained onboard the Phobos-2 spacecraft are used to study the plasma turbulence at frequencies below 10Hz for two crossings of the Martian bow shocks, identified as supercritical, quasiperpendicular shocks. Wave amplitudes inrease throughout the foot region and rearch their maximum values at the shock ramp. Spectra of the magnetic field fluctuations measured in the shock foot exhibit two peaks at frequencies below 0.3 Hz and in the frequency range from 0.4 to 1.5 Hz. The comparison between observations made at the Martian and Earth's bow shocks reveals that the intrinsic properties of the ULF turbulence are likely similar. This fact indicates that ULF waves observed at the Martian bow shock has the same origin, i.e ULF waves are generated by the nonlinear evolution of the shock front.

MARS AND ITS MOONS IN THE SOLAR WIND

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The structure of the Martian magnetosphere is essentially determined by the direct interaction of the solar wind with the planetary exosphere/ionospere. After the preliminary results of the Mars Global Surveyor mission it has been confirmed that Mars has no global dipole field which is strong enough to explain the observed shape and position of the bow shock. It is shown that this apparently existing discrepancy dissolves if instead of MHD description a bi-ion fluid model is used. A proton boundary ('protonopause') is formed, which stops the protons but is penetrable for the IMF due to the flow of heavy ions. Results of 2D simulations are presented. New exciting results were found about the solar wind response on Phobos and Deimos. It is concluded that the significant solar wind disturbances seen in large distances from Mars are caused by the moon's gas/dust tori.

ELECTRIC CHARGE OF NON-SPHERICAL DUST PARTICLES AND DYNAMICS OF DUST PARTICLES IN PLANETARY MAGNETOSPHERES

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Dust particles in space are generally electrically charged. Up to now, for a simplicity, only charges of spherical particles have been considered. Dust particles can be, however, highly non-spherical. Non-spherical particles can carry at a given potential and mass more electric charges and, therefore, can have higher charge-to-mass ratio compared to spherical ones. For example, keeping the mass and the potential constant, the total electric charge on conducting prolate and oblate spheroids increases with increasing ratio of the major to the minor axis. Charges on conducting dust particles of various shapes were calculated with help of the Simion 6.0 program. Implications of results for a dynamics of dust particles in planetary magnetospheres are discussed.

ION TEMPERATURES IN THE IO PLASMA TORUS

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A set of ground-based spectroscopic observations of [SII] emission from the Io plasma torus is described. The Doppler-resolved spectra show that the perpendicular ion temperature decreases with Jovicentric distance beyond 6.0 R_J and increases with distance from the plasma equator. Using a simple model, a "Kappa"-distribution provides a reasonable fit to our data. It is also shown that ion temperatures measured by the Voyager 1 plasma sciences investigation (PLS) can be fit in a similar manner with the same parameters. This provides a possible explanation for the apparent increase in ion temperature with jovicentric distance seen in the PLS data.

DYNAMICS OF THE JOVIAN MAGNETOTAIL

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The Energetic Particles Detector (EPD) onboard the Galileo spacecraft provides comprehensive observations of the hot plasma environment in the Jovian magnetotail region which allowed for the first time to delineate spatial boundaries within the tail from temporal variations. The most prominent features in the inner to middle plasma sheet are distinct quasi-periodic variations of the ion intensities and spectral shape which are superimposed on the well-known 10-hour modulation due to the planetary rotation. They are clearly of temporal nature with a characteristic modulation period of about 3 days. The oscillations are associated with a change of the flow pattern from a co-rotational flow to an increasingly tailward stretched flow pattern. These quasi-periodic modulations are possibly closely related to repetitive particle flow bursts frequently observed in the distant tail. We tentatively suggest that the observations can be attributed to a large-scale reconfiguration process with an inherent time constant. The process resembles in many aspects the dynamics of the Earth's magnetotail during substorms.

Waves in magnetized plasmas: two fluid wave equation formulation

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The theoretical study of waves in magnetized plasmas is often carried out by making use of the conductivity and dielectric tensors. We present a formalism using analogous MHD fluid variables, which does not require the use of either these quantities. The result is a system of coupled wave equations cast in terms of the characteristic variables of the system and limited only to the fluid approximation. These variables turn out to be operations on the electric field, namely its divergence, parallel elongation and its parallel curl. The advantage of this formulation is the transparent physical interpretation of the propagation characteristics of these variables. We illustrate the usefulness of our approach by considering several special frequency regimes and comparing the results to these well-documented cases.

Stationary incompressible MHD perturbations generated by a current source in a moving plasma

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We consider the inductive interaction between a conducting body and a magnetized incompressible plasma in relative uniform motion, which has application to the Io-Jupiter system, for example. An incompressible plasma only supports one mode of propagation, namely the Alfvin mode. In the case of free oscillations, this mode propagates the perturbations in the magnetic field and in the plasma velocity unattenuated along the direction of the background field, while the plasma pressure balances the magnetic pressure. The situation changes in the presence of source currents and in a flowing plasma. In particular, the parallel plasma vorticity and parallel plasma current are propagated unattenuated along the familiar Alfvin characteristics, while the field and velocity perturbations suffer Laplacian decay in the near field. We study these perturbations in the frame of the body, and compare them to the case of no source terms.

ENTIRE MOTION OF A PLASMA SHEET: MHD THEORY

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One important issue in space plasma physics is the dynamics of a current sheet such as the terrestrial plasma sheet, Jovian current disk, heliospheric current sheets, filaments of the solar chromosphere and corona, and bow shocks and magnetopauses of the planetary magnetospheres. This topic could also be important for dense plasma inside plasma laboratories or stars as well. We have studied large-scale coherent motions of the plasma sheet such as flapping or tearing of the entire plasma sheet with consideration of non-uniformity due to the background cross-sheet current. Basic assumptions in this MHD treatment are rapid decay of the wave energy outside the current sheet, uniformity in the sheet current direction, and neglect of kinetic effects. The analysis leads to modified dispersion relations for the linear MHD fast and slow waves which contain imaginary parts because energy is exchanged between the waves and the background sheet current. A short-wavelength MHD slow wave (thick plasma sheet approximation near Earth) propagating against/along the magnetic tension force is unstable/stable, whereas the situation is reversed for the MHD fast wave. For a thin current sheet (long-wavelength limit) near the neutral region, the MHD slow wave becomes stagnant and very unstable, whereas the MHD fast wave propagates slowly and its stability depends on the strength of the background current. These instabilities are similar to but different from the tearing mode instability.

PS5 Small bodies of the solar system

Convener: Schwehm, G.H.
Co-Convener: Ulamec, S.

IONS IN COMETS C/1996 Q1 (TABUR) AND 46P/WIRTANEN

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Comets C/1996 Q1 (Tabur) and 46P/Wirtanen were observed at Pik Terskol (Northern Caucasus) with the 2m-Zeiss-Telescope of the International Centre for Astronomical, Medical and Ecological Studies, Kiev, on October 6-7, 1996 and March 11, 1997, respectively. The two-channel focal reducer of the MPAe was used. The comets were observed with interference filters centered at 614 nm (H_2O^+), 426 nm (CO^+, only Tabur) and with a continuum filter. We derive and discuss the column density distribution of the ions and their temporal evolution. The results will be compared with a theoretical model derived by Wegmann et al. (submitted to Planet. Sp. Sci.), which allows to determine the water production rate from the observed H_2O^+ column density distribution.

CONSERT EXPERIMENT FOR THE ROSETTA MISSION

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In this paper, we describe the experiment CONSERT and its technical solutions. The time domain transponder technique which is used is deeply described, as well as its technical implications. The suitability between the science experiment and the solution adopted is shown. The whole chain : transmitter, receiver and antennas on the orbiter and on the lander, its synchronisation and its specifications are discussed, as well as the electronic solution we adopted. Finally, we present the antenna, its mechanical solution and its transmission characteristics.

COMETARY DUST CHARACTERIZATION BY LABORATORY EXPERIMENTS ON SILICATES GRAINS

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We have produced in the laboratory different kinds of cosmic grain analogues using laser ablation, arc discharge and grinding methods. With this techniques we have been able to obtain grains of different materials both in amorphous and in crystalline phase. Modelling works have shown the presence of submicron grains as responsible materials of cometary coma emission. Olivine particles are thought to be one of the main cometary coma solid particle components. In this work we report infrared spectra obtained at a resolution of 0.25 cm^{-1} for dust grains of different silicates, with average size greater than few tenths of microns. Moreover, Raman spectra of different olivine type grains are shown to evidence their structural properties. The comparison of our laboratory data with Hale-Bopp coma ground-based and ISO spectral observations allows us to derive interesting hints about the nature of the cometary grains and their size distribution.

INFLUENCE OF THE ENERGY INPUT ON THE VAPOR FLUX AND ON THE TEMPERATURE DISTRIBUTION OF COMET NUCLEIS

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Understanding the power balance at the surface of the nucleus is essential to study the chemical and physical evolution of a comet. Therefore, we present a detailed energy budget analysis for the surface of a model comet in the orbit of P/Wirtanen, target comet of the European space craft mission Rosetta, for a variety of parameters and assumptions. We will show that for a fast spinning Jupiter-family comet like P/Wirtanen with a rotation period of about 6 hours a fast rotator approximation underestimates the effective energy input. This yields to lower gas fluxes from the surface. For an active, non dust covered surface we obtain a water gas flux on the order of about of 2. * 10^{28} molecules s^{-1}. This value is within the order of measured values for comet P/Wirtanen at perihelion. But the calculated values are maximum gas fluxes at noon - not averaged over one cometary day or taking lesser insolation of the pol areas into account. Therefore we conclude that maybe the determined radius of comet P/Wirtanen is much larger than the value of about 700m. A radius in the order of 2 or 3 km seems to be more likely to explain the measurements. One other possibility could be that water ice particles are blown off from the surface like dust particles. This may also increase the effective surface area of sublimation

MONITORING OF H2O PRODUCTION OF SEVERAL COMETS FROM LY- ALPHA MEASUREMENTS WITH SOHO/SWAN

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TheSWAN instrument on-board SOHO is able to map the Lyman- alpha emission of comets. From the analysis of the intensity pattern, the Hydrogen production rate coming from the photo-dissociation of water vapor may be estimated, as well as the water production rate. We report the results on several comets near perihelion and at far solar distance, including Hyakutake, Hale-Bopp, Wirtanen, and other faint comets. For several comets, the determination of H2O production rate made by SWAN was unique, because other spacecraft (HST, ISO) were not able to look near the sun, while SWAN may approach within a few degrees of the Sun. These results demonstrate the potential of Lyman-alpha measurements for the monitoring of cometary gas production.

DYNAMICS OF FRAGMENTS OF COMETARY NUCLEI: APPLICATION TO C/1996 B2 HYAKUTAKE

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Fragmentation of cometary nuclei is a rather frequent phenomenon. The fragmentation mechanisms and the dynamics of the fragments are not yet well understood. In order to study the motion of the fragments in 3 dimensions, we propose a general approach based on classical mechanics. This approach is applied to comet C/1996 B2 Hyakutake in the coma of which bright condensations were observed during March 1996. The nature of the condensations is discussed in view of our model results. Comparisons are made with several split comets.

OBSERVATIONS OF KUIPER BELT OBJECTS WITH BTA-6M TELESCOPE: A PHOTOMETRICAL APPROACH TO PROTOPLANET DISC CHEMISTRY

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Three Kuiper Belt objects (KBO) of 23-24 V-magnitudes were observed with BTA-6m Telescope of the Special Astrophysical Observatory, Russia. CCD-photometry in BVRI bands was performed and the spectral curves of the KBOs normalized reflectivity were obtained. By occasion, an unknown Main Belt asteroid passed within 20" next to one of the KBOs in the same frame, which made it possible to compare the colors of the two bodies directly. The normalized reflectivity curves contain information about chemical composition of KBO surfaces that can be revealed by comparison with some laboratory spectra.

THE NASA DISCOVERY STARDUST PROJECT

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STARDUST is the forth in a series of NASA Discovery Missions which will return cometary dust from comet P/Wild-2. These samples are expected to be well-preserved relics of the original solar nebula -- fundamental building blocks of the solar system. STARDUST is highly focused towards its specific mission goals and carries only three instruments that are exclusively designed to collect scientific data: the Sample Collector ; the Cometary and Interstellar Dust Analyzer for real-time determination of chemical composition of dust grains; and the Dust Flux Monitor Instrument determining dust density distribution.

STARDUST engineering subsystems will also be used to provide science value: the Navigation Camera for imaging the coma and nucleus; the radio transmitter for Radio Science during flyby; and the attitude control subsystem which will produce attitude position and rates within the coma.

Mission design, instrument descriptions and expected science return will be described.

MODELLING COMETARY OUTGASSING FROM RADIO OBSERVATIONS

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The shape of emission lines from molecules in comets contains much information about the structure of the inner coma if the spectral resolution is good enough. A model for cometary outgassing is presented, which makes it possible to determine a steady state outgassing pattern by making a fit to the emission line profile. In particular observations conducted in December 1996 of comet P/Schwassmann Wachmann 1 are discussed. This comet is perpetually active through CO outgassing, which has been observed through emission in the submillimeter domain. The outgassing pattern is found to have a strong contrast between the activity on the day- and nightsides of the nucleus. The results improve the confidence in the estimated CO production rate. Application of the idea to other comets is also discussed.

ALTIMETRIC ASSIMILATION INTO PRIMITIVE EQUATIONS MODELS OF THE AZORES-MADEIRA REGION: COMPARISON BETWEEN OPA AND MICOM.

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The aim of that work is to make comparisons between two primitive equations models through altimetric assimilation experiments. The two models have different formulations: OPA (Madec et al., 1997) is a rigid lid model with a continuous representation of the variables on the vertical and MICOM (Bleck et al., 1992) is a multi-layers, free surface model. The assimilation technique is optimal interpolation (SOFA scheme, De Mey, 1994 pers. com.) and the surface misfits between model and data are projected along an isopycnal EOF representing the ocean variability in that region (Gavart and De Mey, 1997) or as in Cooper and Haines (1996). The experiment area is a 1000 by 1000 sq. km open domain of the Azores-Madeira region. A special open-boundary treatment is applied: the area is surrounded by a recirculation zone, separated from it by a sponge layer. 6 months of combined ERS-1 and Topex-Poseidon data are assimilated, from June 1993 to the end of November 1993. That period overlaps the in situ data of the SEMAPHORE experiment (Eymard et al., 1996), and mainly drifting buoy data are used for an objective validation. We discuss the differences between the two models and their sensitivity to different parameters (length of the assimilation cycles, horizontal diffusion, ...).

CCD POLARIMETRIC IMAGING OF TWO SHORT PERIOD COMETS: 81P/ WILD 2 AND 22P/ KOPFF.

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The solar light scattered by dust particles in comets has been observed by CCD polarimetry at Pic du Midi Observatory (France) in June 1996 and February 1997 and at Haute-Provence Observatory (France) in April 1997. This technique of observation allows to enhance different regions in the inner coma that are not easily visible in brightness maps.
We present images of comet 81P/Wild 2 observed at 10 and 36 deg. phase angles and of comet 22P/Kopff observed at 18 deg phase angle. The polarization maps will be compared with those of previously studied comets with the same method at similar phase angles: to study the evolution of the polarization in the different parts of the coma as function of phase angle, to enlarge our knowledge of the physical properties of the dust particles by comparing different comets.

EVALUATION OF MUPUS DATA AND THE INVERSE HEAT CONDUCTION PROBLEM

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Among the experiments selected for the Rosetta Lander of the ESA mission to comet P/Wirtanen is the MUPUS package. One of the tasks of this package is a heat flow measurement at the surface of the nucleus of P/Wirtanen. This is done by determining thermal parameters of the subsurface material (e.g. thermal conductivity, thermal diffusivity) and measuring the temperature profile below the surface by means of a penetrator. A distortion of the subsurface temperature field due to the measurement technique itself is inevitable. Both the shade of the lander and the thermal properties of the penetrator (which are different from those of the nucleus material) result in a significant perturbation of the subsurface temperature field. The first of these problems can be solved by using a deployment device which allows to position the penetrator at some distance from the lander. The perturbation of the temperature field can be reduced by solving the inverse heat conduction problem (IHCP). A method applicable for this transient case of the IHCP is presented. Using this method one can predict the temperature field in the surroundings of the penetrator and thereby obtain an undisturbed temperature profile for the subsurface material.

MUPUS-TM : IR-MEASUREMENT OF COMET P/WIRTANEN'S SURFACE TEMPERATURE

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The infrared sensor TM as part of the MUPUS (Multi Purpose Sensor for Subsurface Science) experiment package onboard the Rosetta Lander is dedicated to the measurement of the cometary surface temperature at the landing site, in dependence of local time and heliocentric distance. Scientific goals are the determination of thermophysical parameters and the derivation of clues on the surface roughness on sub-mm to mm scales, below the resolution of the camera. Furthermore, TM data will provide ground truth for remote sensing instruments on the orbiter, especially the NIR-spectrometer VIRTIS and the microwave radiometer MIRO. To achieve these goals the emitted radiation in the wavelength range 5-25 micron is measured in 4 infrared channels by thermopile detectors. An accurate measurement of the expected low temperatures requires low noise and drift electronics as well as an accurate (in-flight) calibration of the detectors. Furthermore, the unknown conditions at the cometary surface require special inversion algorithms working with a minimum of a priori assumptions.

IMAGING POLARIMETRY AND COLOUR IN COMET C/1996 Q1 (TABUR) AT LARGE PHASE ANGLE

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Polarization and colour images of comet C/1996 Q1 (Tabur) were obtained at Pik Terskol (Northern Caucasus) with the 2m-Zeiss-Telescope of the International Centre for Astronomical, Medical and Ecological Studies, Kiev, on October 9 and 10, 1996. The phase angle was 83°. The two-channel focal reducer of the MPAe was employed in its polarimetry mode with four-beam Wollaston assembly. The device allows simultaneous aquisition of images of the q and u Stokes parameters in two colours through narrow-band filters in a 1 arcmin square window. Filters centered at the cometary continuum bands at 443 and 642 nm were used. In the gassy comet Tabur no dust jets or envelopes are noticed. The polarization value is consistent with the curve of dusty comets provided by Levasseur-Regourd et al. (A&A 313, 327, 1996) and therefore contradicts the idea of a lower polarization of gassy comets, put forward by these authors. The results will be compared with similar observations of comets C/1995 Y1 (Hyakutake) and C/1995 O1 (Hale-Bopp).

X-RAYS IN COMETS: THEORY AND OBSERVATIONS

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X-ray emission observed in eight comets with the ROSAT, EUVE, and BeppoSAX orbiting observatories is a general cometary phenomenon. It is stronger than the expected emission by three orders of magnitude. Four processes have been suggested as basic excitation mechanisms: (1) charge transfer of solar wind heavy ions, (2) scattering of the solar X-rays by very small (attogram) dust particles, (3) line radiation from the cometary plasma (Bingham et al. 1997, *Science 275,* 49), and (4) electron bremsstrahlung (Northrop et al. 1997, *Icarus 127,* 246). We show that the formula for impurity radiation in the fusion plasma used by Bingham et al. is not applicable to the cometary plasma. Recombinations are ineffective in X-ray. Electron impacts produce UV photons and only two X-ray emissions, O 525 eV and C 277 eV, at a level of ≤2% of the observed emission. Corrections for two errors found in Northrop et al. reduce bremsstrahlung to ≤0.5% of the observed emission. Therefore, only processes (1) and (2) may be currently considered. Correlations of X-ray emissions observed with EUVE in four comets with gas and dust production rates as well as the brightness maxima and their offsets from the nuclei, favor charge transfer as the dominant process. However, scattering by attogram dust may be significant in very dusty comets like Hale-Bopp.

CHURGED DUST DYNAMICS ABOVE THE SURFACE OF A COMET FAR FROM THE SUN

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We investigate the dynamics of small dust particles ejected from the sunlit side of the nucleus of a comet far from the Sun. The motion of these particles is determined by gravity, electromagnetic forces, and solar radiation pressure. The nucleus is not shielded from either the solar wind or the solar UV radiation; therefore the surface of the nucleus absorbs electrons and protons and emits photoelectrons. As a result, the surface gets positively charged. Above the nuclear surface a photoelectron plasma sheath forms in which the ejected dust grains collect electrostatic charges and become responsive to the electric field in the sheath. We show that most of the dust cloud created by an impact (e.g., a lander) will settle after a few (~ 4) hours elsewhere and not in the close vicinity of the impact site (i.e., on the lander itself).

IN SITU INTERSTELLAR DUST FLUX MEASUREMENTS AND THEIR EXTRAPOLATION TO THE INTERSTELLAR MEDIUM

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We present the problem of too much dust (in terms of mass) detected in situ by the Ulysses and Galileo spaceprobes. The mass in interstellar dust grains measured in situ is double the mass predicted from depletion arguments (determined using solar reference abundances). We show by numerical simulation that the interaction of the grains with the heliospheric fields can explain the enhancement in number-flux, but is not able to explain the too high mass-flux. We conclude that interstellar dust has to be either locally enhanced on scales smaller than the local interstellar cloud (LIC) or that the grains at the upper end of the mass-distribution are not in equilibrium with the LIC but with larger structures in the local interstellar medium.

THE AGORA PROJECT: 16 YEARS OF GLOBAL OCEAN ANALYSES FOR STUDIES OF CLIMATE VARIABILITY.

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The Derber and Rosati (1989) Optimal Interpolation (OI) scheme has been used to assimilate the latest World Ocean Atlas data set of Levitus (1994) for temperature vertical profiles and the weekly sea surface temperature reanalysis from the Climate Prediction Center (Reynolds and Smith, 1994). The assimilation scheme is a univariate, variational optimum interpolation of temperature only in which the first guess is produced by a global ocean general circulation model. The model is a modified version of the Modular Ocean Model (Cox, 1984; Rosati and Miyakoda, 1988) implementation to the global ocean. Twice daily ECMWF atmospheric analyses are used to force the model. The study period is 16 years starting from January 1981 ending december 1996.
A comparison of analyzed sea surface height with sea surface height from Topex/Poseidon data computed by the AGORA project partners will be carried out.

THE ROLIS IMAGING EXPERIMENT ON THE ROSETTA LANDER

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The ROLIS experiment is part of the payload on the Rosetta International Lander. The instrument consists of a highly integrated and lightweight CCD imager with a dual capability. Firstly during the descent phase of the lander, just before touch-down, the imager will acquire a sequence of panchromatic pictures of the landing site. These images, which will have a spatial resolution of the order of a few millimeters, will give context to the measurements performed in-situ by the lander payload. Secondly, after landing, the camera will be focused to a close-up distance of 30 cm, from which it will be possible to image regions below the lander with a spatial resolution of a few tenths of a millimeter. Furthermore, an autonomous, trichroic illumination system will enable color images to be acquired. Coupled with the rotation capabilities provided by the main compartment of the Lander, ROLIS will be able to acquire color images of the areas from which samples will be collected and analyzed by the other Lander instruments.

PHOTOMETRICAL APPROACH TO PROTOPLANET DISC CHEMISTRY

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Three Kulper Belt objects (KBO) of 23-24 V-magnitudes were observed with BTA-6m Telescope of the Special Astrophysical Observatory, Russia. CCD-photometry in BVRI bands was performed and the spectral curves of the KBOs normalized reflectivity were obtained. By occasion, an unknown Main Belt asteroid passed within 20" next to one of the KBOs in the same frame, which made it possible to compare the colors of the two bodies directly. The normalized reflectivity curves contain information about chemical composition of KBO surfaces that can be revealed by comparison with some laboratory spectra.

INVERSION OF SHAPE STATISTICS FOR SMALL SOLAR SYSTEM BODIES

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The irregular shapes of small solar system bodies are modeled by lognormal statistics, i.e., assuming that the shapes are realizations of the so-called Gaussian random sphere. The Gaussian sphere is fully described by the mean radius and the covariance function of the logarithmic radius. The stochastic shape is thus given by the covariance function, or the discrete spectrum of its Legendre coefficients. A maximum likelihood estimator is here provided for inverting the covariance function from three-dimensional sample shapes. The inverse method is applied to shape data on altogether 14 small solar system bodies. Inversion yields $\sigma = 0.245$ for the relative standard deviation of radius, shows that most of the spectral power lies in the second-degree spherical harmonics, and gives $\Gamma = 32.7°$ for the correlation angle. Even though the first results are promising, precaution is recommended because the number of sample shapes is still small. As an example application, thermal light curves are simulated for 1000 Gaussian sample spheres in order to study the uncertainties in diameters and masses derived for asteroids. As compared to the Standard Thermal Model that assumes spherical asteroids, the irregular shape is shown to cause a 10 % scatter in diameter estimation, and a 17 % systematic effect and a large 33 % scatter in mass estimation.

REGIONS AND BOUNDARIES OF COMETARY PLASMA ENVIRONMENTS

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We examine and intercompare the plasma regions and boundaries between bow shock and cometopause at three comets: Giacobini-Zinner, Halley and Grigg-Skjellerup. The question is discussed: are boundaries the stable structure or they appeared by time non-stationary phenomena? The main properties of these boundaries are: change of ion content, gradient of high energy electron density, rotational discontinuity of magnetic field **B**, depression of **B** module, appearance and jump of ULF wave intensity. Doubtless, the boundaries positions are related with mass flow, sublimated from comet surfaces. However for comet Halley time variations of rotational discontinuity coincide with time variations of Solar wind (SW). It is argument in favor, that boundaries properties are resulted of interaction with SW and related with its properties.

MODELLING THE NUMBER DENSITY PROFILES OF SECONDARY DUST COMPONENT OBSERVED ONBOARD THE VEGA SPACECRAFT

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The two Vega spacecraft have observed a dust boundary, which was common to all grain masses over the range ~1.e-17-1.e-7g, both inbound and outbound. Slow disintegration of dust aggregates seems to be the only way for this boundary to be formed. A model of the boundary formation (Oberc, Icarus 124, 195-208, 1996) has allowed to draw from observations the latent heat (~16 kcal/mol) of the gluing compound and the size range (0.01-1 cm) of aggregates responsible. The purpose of the present work is to model number density profiles of secondary particles along the Vega trajectories. It is shown that particles observed near the closest approach, for that d << v^2/2gb (d - distance to closest approach, v - velocity of the parent aggregate, g - solar gravity acceleration, b - ratio of solar radiation pressure over gravity force for the secondary particle), originated mostly in a narrow zone sunward of the Vega trajectory. Hence, their number density was very sensitive to variations in the emission rate of aggregates from the nucleus. This 1) explains the peculiar effects in the profiles of ~1.e-7g particles, found in count rates from the DUCMA V (veto) detector, which implies that 2) such particles were predominantly of secondary origin, and 3) primary particles in this mass magnitude were mostly aggregates which (almost) totally disintegrated before reaching the Vega trajectory.

PS5

THE GIADA EXPERIMENT ONBOARD ROSETTA MISSION TO COMET 46P/WIRTANEN: PERFORMANCES AND CAPABILITIES

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The GIADA (Grain Impact Analyser and Dust Accumulator) Team is responsible for a scientific payload for the Rosetta mission able to measure dust flux dynamic parameters in cometary coma. A first set of sensors (MBS - Micro-Balances System) is based on 5 quartz crystal micro-balances, with the sensitivity to measure very small mass, both cumulated and from a single particle, deposited on the sensing surface. It will be used to derive the flux from different direction inside the coma. Another subsystem (GDS - Grain Detection System) is used to detect the transit of single particles, and together with the third sensor (IS - Impact Sensor), which measure the momentum, is able to determine velocity and mass of the impinging cometary particles. The status of the experiment, its foreseen and measured performances and the scientific capabilities will be discussed.

UPPER LIMITS FOR THE HYDROCARBONS IN THE INNER COMA OF COMET P/HALLEY

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During the encounter of the Giotto spacecraft with comet P/Halley the HIS sensor of the IMS measured continuous ion density profiles in the mass range 12-56 amu/e, starting from about 130000km distance to the nucleus up to 1300km. In order to derive the abundances of parent molecules from measured ion densities inside the inner coma a chemical model has to be used which includes the most important ion production and loss mechanisms and ion-molecule reactions. The reactions of the hydrocarbons C_2H_2, C_2H_4 and C_2H_6 and of the carbon molecule C_2 were added to the existing chemical model. With this it is now possible to distinguish between the different contributions of each hydrocarbon to the ion densities in the mass range 24-30 amu/e. Of special interest is the ion density at mass 24, which attributes entirely to C_2^+ since interferences with other ions of the same mass are negligibly low. Thus, the comparison of the measured ion densities at masses 24-30 amu/e with the simulated ion densities leads to an upper limit for the hydrocarbons C_2H_2, C_2H_4 and C_2H_6 contained in the volatile material of the comet.

BISTATIC RADAR OBSERVATIONS OF COMETARY NUCLEI

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One of the scientific objectives of the Rosetta Radio Science Investigations experiment is the bistatic radar observation of the nucleus of comet P/Wirtanen. The bistatic radar configuration distinguishes itself from monostatic radar by the spatial separation of transmitter (in this case Rosetta) and the receiver (antenna on Earth) and thus views the target from other than the backscatter direction. By observing the amplitude, frequency and polarization of a radio signal transmitted from the spacecraft and reflected from the nucleus surface, the rotation and precession rate of the nucleus can be determined and estimates of the dielectric properties and the roughness of the surface can be derived.

THE INTERNATIONAL ROSETTA MISSION

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Rosetta is the third cornerstone in ESA's long term programme. Launched in 2003 it will rendez-vous with comet 46P/Wirtanen in 2011 and will accompany the comet from near-aphelion through perihelion. On the way to the comet two close flybys at asteroids are in the mission baseline. After the initial nucleus mapping phase a lander will be deployed onto the nucleus to provide in-situ science.

The mission will concentrate on the study of the composition of the comet and the evolution of the cometary phenomena. The payload includes a suite of remote sensing instruments (UV, VIS, IR and sub-mm), mass spectrometers to study the composition of the volatile and non-volatile constituents and instruments to monitor the cometary environment.

Mission design, payload description and expected science return will be described.

EVOLUTION OF THE TOPOGRAPHY OF REVOLVING COMETS ANALYSED BY NUMERICAL MODELLING

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Comets are interplanetary bodies and their nucleus is composed of a mixture of non-volatile grains and frozen gases. They usually rotate and follow highly elongated paths around the Sun. Comets of the Jupiter family have their aphelion near the Jupiter orbit and their perihelion near to the Earth orbit at 1 AU. These comets dwindle in the order of 1 meter per orbit, as deduced from the observed outgasing rates and nucleus extensions. We simulate the time - dependent evolution of comet model topologies and surface roughnesses. The plain model assumes the surface loss to be proportional to the incident solar radiation and takes the rotation of the nucleus into account. We will discuss the effects and modifications of various initial surface roughnesses, scale heights and cometary shapes.

NUMERICAL SIMULATION OF THE ORBITAL EVOLUTION OF SOME NEAR-EARTH ASTEROIDS

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Some near-Earth asteroids are considered to be the extinct or dormant nuclei of periodic comets. Among them are asteroid 4015 Wilson-Harrington and 2210 Oljato. We can expect that such objects may come from both the main asteroid belt and the reservoir of short-period comets into its current planet crossing orbit.

The forward-backward orbital evolution of such comet-asteroid transition objects was investigated by integration for a long-time interval (6000 years) of a dynamical model, consisting of all planets and massless asteroids. For determination the positions of planets the ephemeris DE404 was used. For the numerical simulation of asteroid motion the new effective method DINCH of numerical integration was applied. Parallel with orbital elements a constant Jacobi C was selected as a parameter under investigation. In the restricted three body problem the constant $C = C(L)$ often uses as a criterion of determination of unstable orbits. The detailed analyses of the evolution of selected orbital parameters included also the comparison of calculated $C(t)$ and known values of Jacobi constants $C(L_{ij})$ at 4 libration points for the main disturbing planets.

All results of the investigation are presented in the form of diagrams and graphs.

Rosetta Lander - In Situ Investigation of a Cometary Nucleus

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The ESA cornerstone mission Rosetta to comet P/Wirtanen, includes a Lander with an overall mass of about 85 kg,. After ejection from the Rosetta-Orbiter, this Rosetta Lander will descend to the surface of the target comet supported by a cold gas system. It should operate for a large fraction of the cometary orbit around the sun, between 3 and 1 AU. Solar cells, covering the surface of the lander will provide the power to operate the system and a scientific payload of about 20 kg, measuring the chemical, physical and mineralogical properties of the cometary surface material, the internal structure of the nucleus and take images of the landing site. The lander is an autonomous station, using the Rosetta orbiter as a relais to Earth. Due to its longevity it is possible to study time dependent cometary phenomena and to investigate modifications of the surface due to increasing insolation.

PS6 Solar system radiophysics and related topics

Convener: Barrow, C.H.
Co-Convener: Aubier, M.G.

TO THE FORMATION MECHANISM OF THE DECAMETER JOVIAN RADIOEMISSION S-BURSTS WITH COMPOUND TYPES OF FREQUENCY DRIFT

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The mechanism of the formation of short-periodic (S) decameter Jovian radioemission bursts with compound types of frequency drift is proposed. The explanation is based on Cherencov(s emission mechanism of plasma waves with an anomalous dispersion and on influence of low-frequency hydrodynamic waves (which perturbate the surface of the flux tube Io-Jupiter) on the such parameters of the tube as electron density and magnetic field. On the basis of the proposed mechanism analysis of experimental data is made. The values, which provide the experimentally observed properties of S-bursts with compound frequency drift and without anyone are obtained. It is shown that bursts without frequency drift can arise if the certain condition between local variations of electron concentration and magnetic field take place. The estimations show that found scales of inhomogeneity correlate with the scales of low-frequency hydrodynamic waves providing the observed periodicities of dynamic spectra of Jovian S-radioemission.

THE JOVIAN HOM RADIO EMISSION OBSERVED BY WIND/WAVES AND BY ULYSSES/URAP

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During 1995 to 1997, the jovian hectometric radio emission (HOM) was received occasionally at kHz frequencies by the Radio and Plasma Wave Investigation (WAVES) receivers on board the WIND spacecraft. Dynamic spectra of these observations have been compared with simultaneous spectra made by the Unified Radio and Plasma Experiment (URAP) receivers on board Ulysses. Several events can be identified by shape and structure in the dynamic spectra from both spacecraft although the durations and the frequency ranges are not always the same in each spectrum. This may be a manifestation of the beaming characteristics of the HOM. The results are presented and discussed.

Jovian Millisecond radio bursts: Phenomenology and Morphology

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The Jovian decametric emission (DAM) is known to exhibit fine structures, the so-called "S-bursts". The probability occurrence of S-bursts represents a significant fraction ($\simeq$ 10%) of the DAM radiation. During more than 20 years three ground-based radiotelescopes (Tasmania , Australia; Oulu , Finland; Florida, U.S.A.) using receivers with high time and frequency resolutions collected the main details of the Jovian millisecond radio bursts. We analyse the phenomenology and the morphology of the previous observations as reported in catalogues (Ellis, 1979; Flagg et al., 1991; Riihimaa, 1991). It clearly appears that the S-burst characteristics (drift-rates, bandwidth, periodicity...) could be affected by the antenna (sensitivity, frequency bandwidth) and receiver parameters (resolutions in time and frequency).

RADIO SOURCES ASSOCIATED WITH INTERPLANETARY CMES

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We review the main questions raised by the observation of radio emissions associated with Coronal Mass Ejections (CMEs) and we discuss the first WIND/WAVES observations of interplanetary type II radio bursts and of other interplanetary or coronal events. We compare these results to previous ISEE-3 observations and we discuss the role of radio observations in tracing the evolution of interplanetary CMEs. We find that, if some cases are quite clear and suggest that the radio radiation is produced in the CME driven shock, other cases are much more complex and will certainly require more work –and other observations– to be fully understood. We discuss the role of these observations to predict earth impact of the interplanetary CME.

DETERMINATION OF SOME PARAMETERS OF FLARING LOOPS FROM RADIO DATA IN 13.5-17.1 GHZ FREQUENCY RANGE

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The data of 8 middle solar bursts obtained using spectrograph with frequency resolution $\delta f \sim 100$ MHz and sweeping time $\tau \sim 0.67$ sec. during high solar activity have been analysed.

There were determined the following parameters of flaring loops: the scale of beam driven plasma turbulence ~ 6 angular seconds, the length of electron concentration inhomogenity along flaring loop ~ 6000 km. It was used the idea of plasma turbulence radioemission mechanism from thermal fronts of energy release regions in flaring loop and our diagnostic procedure.

This results are in accordance with similar recieved earlier in 8–12 GHz range.

WIND/WAVES, NANCAY DECAMETRIC ARRAY AND NANCAY RADIO HELIOGRAPH OBSERVATIONS OF AN INTERPLANETARY RADIO STORM

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We present the first observation of an interplanetary radio storm consisting of thousands of type III radio bursts which were tracked by the WAVES experiment on the WIND spacecraft in September 1997. These events could be traced back to the solar corona where they were detected by the Nancay Decametric array and they are closely associated with a type I storm which was observed by the Nancay Radio Heliograph. We discuss the development of the active region and its extension in interplanetary space. We will briefly review previous similar observations by the ISEE-3 spacecraft and discuss the new approach of the ISTP era.

JOVIAN S-BURST DRIFT MODEL IMPLYING A PARALLEL ELECTRIC FIELD

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We study the effect of a parallel electric field on the adiabatic motion of electrons trapped in the Io flux tube. In the frame of a dipole magnetic field model and supposing that the mechanism responsible for the radio emission is the cyclotron maser instability taking its free energy is a loss cone, we derive the frequency drift rate of the S-bursts emitted at the gyrofrequency. The influence of the parallel electric field on the conditions for emission is discussed. We propose an individual fit of the instantaneous frequency drift rate of certain types of S-bursts, in particular the *type a* of Riihimaa's classification, which only depends on the energy and the pitch angle at the equator and on the value of the parallel electric field. This fit should allow to accede to the parameters of the radiating electrons (i.e. velocity and pitch angle) directly from the instantaneous drift rates observed on dynamic spectra.

ON A MODEL FOR MILLISECOND SOLAR RADIO SPIKES

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A new model for solar spike bursts is considered based on the interaction of Lengmuir waves with ion-sound waves: $l + s \rightarrow t$. Such mechanism can operate in shock fronts, propagating from a magnetic reconnection region. New observations of microwave millisecond spikes are discussed. They have been observed in the event 1997.11.04 between 0552-0610 UT using multichannel spectrograph in the range 2,6-3.8 GHz of Beijing AO. Yohkoh SXR images testify a reconstruction of bright loops after the escape of CME of type halo visible at 0610 UT at LASCO 2 coronograph onboard of SOHO. Strong left polarization of spike emission from a source above the leader spot of south magnetic polarity in AR 8100 corresponds in this event to the extraordinary magnetoionic mode. The model gives the ordinary mode of spike emission, therefore we propose the depolarization of the emission in the transverse magnetic field and rather in the vanishing magnetic field in the middle of QT region. The scattering of O-mode into X-mode by whistlers just above the escape level of X-mode can also provide an additional depolarization. Duration and frequency band of isolated spikes are connected with parameters of fast particle beams and shock front.

STUDY OF THE TWO REMOTE ACTIVE REGIONS CONNECTION ON MAY 1993

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This research has been performed in the frame of the collaboration between the Meudon and Wroclaw observatories. Activity of 3th May 1993 occurred on east limb of the Sun and was observed in Wroclaw by means of the Small Coronagraph. It was associated with radio sources observed by the Nançay Radioheliograph. The same regions were observed also on the opposite limb on 13th and 14th May by the same equipment. During the first day of the observations, as well as the next ones, both the optical events and the redio sources were occurring in two remote regions in turn, pointing to an existing connection of these two regions by a big magnetic loop spanned over the solar equator.

STRUCTURE OF X-POINT IN SOLAR CORONA AS NONLINEAR KINETIC PROBLEM

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Magnetic reconnection in solar corona like in Earth magnetosphere more adequate to study in kinetics. The reason is that plasma is hot and collisionless, dynamics of the reconnection process is slow. We can find resonant and nonresonant effects in interaction plasma - inductive e.m. field, the effect can not be studied in MHD. The key point of reconnection are X-points of unmagnetized plasma where we have current carrying plasma with not prescribed structures of fields, currents, flows etc. This structures are treated via liner study of dispersive (diamagnetic, conductive) properties of collisionless hot plasma . For prescribed configuration of plasma with an anisotropy due to current in a linear approach we have structures from TE and TM modes. Selfconsistent study of current formation can be done only by nonlinear terms. We have current formation from resonant and nonresonant particles under accelerating action from applied electric field at X type magnetic field. This process which takes into account discrete particle structure of plasma we study in laminar and turbulent approach. \\[2cm]

SOME WIND AND ULYSSES OBSERVATIONS RELATING TO THE ORIGIN OF TYPE III BURSTS

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The primary Langmuir waves which give rise to Type III solar radio bursts are generated, at 1 AU, by electrons in the few Kev energy range, and as a consequence, the resonant frequency lies very close to the local plasma frequency, a few tens to hundreds of Hertz above it. Therefore it is necessary to take into account both the magnetic field, as the electron cyclotron frequency is comparable to this frequency difference, and plasma frequency fluctuations, as was done in calculations by Krauss-Varban (1989)
Data from type III bursts collected by the the Waves experiment on Wind will be shown to illustrate these effects. Data from the Earth's foreshock Langmuir waves further elucidate the processes.
It is of interest to understand the wave modes involved in the density fluctuations, as these determine frequency diffusion in the interaction process. Data from Ulysses as well as from Wind-Waves which bear on mode determination will be presented.

ULYSSES-WIND SIMULTANEOUS OBSERVATIONS OF SOLAR TYPE III KILOMETRIC RADIO BURSTS ASSOCIATED WITH LANGMUIR WAVES

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In order to identify the emission mode and directivity of Interplanetary type III kilometric radio bursts, we have analysed simultaneous observations of these emissions from the Ulysses and Wind spacecraft. Wind is stationed near Earth at 1 AU ; Ulysses is widely separated from Wind in heliocentric distance, longitude and latitude. For this study, we have selected some type III bursts which are associated with Langmuir waves detected at one spacecraft. The electrons responsible for the radio emission are known to travel along the approximate spiral magnetic field lines from the Sun to the spacecraft where they generate Langmuir waves locally. From the other spacecraft, we observe the same radio burst with some delay because of a different propagation path. We then compare the burst onset times and intensities at the two spacecraft with the predicted onset times and distances of the source regions as deduced from the assumed spiral trajectory of the type III electron streams, for both the fundamental and harmonic emissions. The main result is that type III bursts radiate at both modes with different directivities. At large angles from the spiral field lines, only the harmonic emission could be observed due to its broader radiation pattern.

TECHNICAL ASPECTS IN THE OBSERVATION OF FAST, TIME-VARYING RADIO EMISSIONS FROM SOURCES IN THE SOLAR SYSTEM.

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An appropriate antenna/receiver/analyzer combination is a prerequisite for studying radio emission phenomena. The increase of eceiver/analyzer performance - being possible by the use of digital techniques - may lead to a better understanding of the physics behind the wave generation process. This technology is not limited to ground-based observations but may also be used on spacecraft in the future. In this presentation the author tries to outline some of the new possibilities the technology offers. The question, whether the classical concept of short-time spectra is appropriate for studying rapidly evolving radio emissions - such as the Jovian S-bursts - will be addressed.

Jovian Radio 'Bullseyes' Observed by Ulysses URAP

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During the several month interval in 1991 and 1992 when the Ulysses spacecraft was within about 1 AU of Jupiter (as well as some isolated cases much farther away), the low frequency radio receiver (<50 kHz)subsystem of the Ulysses URAP instrument detected several (10-20) episodes of signals that had the appearance of partial 'bullseyes' (i.e. a central bright spot partly surrounded by concentric bright circles) when displayed on frequency versus time dynamic spectra. These 'bullseye' features were of certain Jovian origin, not only because of their relatively high occurrence when Ulysses was near Jupiter, but also because there were some cases when the bullseye features recurred at 10-hour intervals. There was a strong tendency for the events to be observed when the Jovian South dipole nodded toward the spacecraft. The occurrence pattern also showed a roughly 25-27 day periodicity. Similar features were not reported during the Voyager era. We describe these features and their possible correlation to structures in the solar wind impinging on the Jovian magnetosphere. We speculate on the nature of the features and discuss the possibility of unusual propagation conditions in the Jovian magnetosphere.

PROPAGATION OF ELECTRON BEAM IN THE LOW CORONA

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Dynamic of electron beam flying-off is considered in case initial electron distribution is localised in space region. Equations has been solved using gas-dynamic approach within theory of weak turbulence. Numerical analysis and analytical consideration of the initial problem of monoenergetic electron beam flying-off with parameters characteristic for the low corona show that electron propagates into plasma depth as a beam-plasma structure with constant velocity. Speed of the beam-plasma structure is equal to the half of the maximum velocity of electrons involving in this structure. Since this structure consists of not only electrons but plasmons we have possibility to obtain strict expressions for transverse waves radiation within plasma emission model. Dependency of spectral energy density of Langmuir waves on phase velocity is analytically obtained and it is compared to numerical results. It is shown that analytical values are in an exellent agreement with numerical solution of kinetic equations.

TRACING THE ELECTRON DENSITY FROM THE CORONA TO 1 AU

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We derive the electron density distribution from the low corona to 1 AU using observations made from 13.8 MHz to a few kHz by the radio experiment WAVES aboard the spacecraft WIND. We concentrate on type III bursts whose trajectories intersect the spacecraft, as determined by the presence of burst-associated Langmuir waves, or by energetic electrons observed by the 3-D Plasma experiment. For these bursts we are able to determine the mode of emission fundamental or harmon ic, the electron density at 1 AU, the distance of emission regions along the spiral, and the time spent by the beams as they proceed from the low corona to 1 AU. By measuring the onset time of the burst at each frequency we are able to derive an electron density model all along the trajectory of the burst. For all of the bursts considered, the emission mode at burst onset was the fundamental; by contrast, in deriving most previous models, harmonic emission was assumed. Our density model is compared to the existing models and those derived from direct, in-situ measurements. One implication of our results is that isolated type III bursts do not usually propagate along dense regions, as it is still sometimes assumed.

A GLOBAL SURVEY OF THE JOVIAN MAGNETOSPHERIC ACTIVITY, POSSIBLE RELATIONSHIP WITH THE IO ACTIVITY

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Large scale energetic phenomena that would be consequences of explosive releases of energy in the jovian magnetosphere are recurrently detected by the Galileo PWS experiment Their onsets are indicated by sudden detections of bursts of kilometric radiations (b-KOM), followed by intensifications of the auroral radio emissions (DAM and HOM). They also correspond to important reorganizations of the sources of the n-KOM and modifications in the structure of the magnetodisc. These energetic events present obvious analogies with the geomagnetic substorms. An hypothesis would be that they are directly linked to instabilities that develop in the outer regions of the Io torus. We present a global survey of these energetic events corresponding to an analysis of 2 years of observations. It is shown that the periodicity of these energetic events varies from less than 50 hours to more than 100 hours. This could be related to variations in the activity of Io and, more precisely, to variations in the flux of matter escaping from this moon.

A DIGITAL SPECTRUM ANALYZER FOR GROUND BASED DECAMETRE RADIO ASTRONOMY

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We describe the first observing results of a new spectrum analyzer for ground based, decametre radio astronomy, which has been developped at the Paris-Meudon Observatory in collaboration with the Space Research Institute of Graz. We discuss the design of the analyser, mainly driven by the man made radio interferences problem, and present observations of celestial bodies (including Jupiter, the Solar Corona and some galactic radio sources) which have been obtained with the Nancay Decameter Array during the second half of 1997. At the light of these observations, we emphasize that direct digital signal processing techniques will presumeably play an important role in the future radio astronomy.

RADIO EMISSION FROM SHOCKS IN THE HELIOSPHERE

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In the solar corona flares and/or coronal mass ejections can generate shock waves. A part of them is able to penetrate into the interplanetary space. These shock waves appear as so called type II bursts in dynamic radio spectra. But other shock waves, e. g. planetary bow shocks and the helispheric termination shock, are also emitting radio radiation. This property indicates that these shocks must be able to accelerate electrons up to suprathermal velocities. Different acceleration mechanisms acting at shock waves in the helisophere are presented and, subsequently, compared with the observations in an quantitative manner.

Wavelet analysis of the ELF radio noises produced by the lightning activity

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The radiation of the lightning strokes observed in the Earth - ionosphere cavity is natural electromagnetic noise of ELF range (4-40 Hz). It can be listed few reasons grounding the actuality of this process investigation: 1) The interferences of receiving ELF signals from the Earth and space sources associated with the lightning emission. 2) Last time the hypothesis has been put forward that the lightning processes exist in the gas shapes of the some Solar System planets (for instance, on Jupiter). The detail investigation of Earth's lightning effects gives possibility to distinguish the lightning process in observing ELF signals. In this work the signals produced by lightning strokes have been analyzed by the wavelet method. It has been shown that the emission of lightning strokes can be regarded as $1/f^{\gamma}$ process (named flicker-noise) with typical values of $\gamma \in [1, 2]$. The graphical results are presented.

A NEW 2-D MODEL OF THE IO PLASMA TORUS

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We present a 2-D kinetic collisionless model of the Io plasma torus based on "anisotropic bi-kappa" distributions to calculate the latitudinal structure (i.e. density and temperature of each particle species along the magnetic field lines), using the nearly equatorial data set from Voyager 1 to empirically design the radial structure, following F. Bagenal[1994]. Our new model basically reconciles the Voyager 1 and 2 and Ulysses observations, and shows that they actually correspond to similar latitudinal and radial variations of the plasma torus densities and temperatures. This model also renders the ion temperature radial profile from Voyager 1 (which is increasing with distance to Jupiter beyond ~7.5 Jovian radii) compatible with a quasi-adiabatic temperature decrease at the torus equator.

SIMULTANEOUS HIGH RESOLUTION OBSERVATION OF A SEQUENCE OF JUPITER MILLISECOND BURSTS AT NANCAY (FRANCE) AND GRAZ (AUSTRIA)

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The observation of a Jovian Io-B event on July 23/24, 1997, simultaneously performed at the radio stations Nancay (France) and Graz (Austria), enabled the first direct comparison of Jovian decameter S-burst narrowband emission on a time scale of milliseconds. The achieved time resolution was 8 ms and 4 ms for Nancay and Graz, respectively, and the frequency resolution was 20 kHz in both sites. Taking into account the respective sensitivites of the two used radiotelescopes and the distance (about 1000 km) between the observing sites, the observations are compared. A detailed quantitative investigation discusses the procedure of a calibration of the Graz instrument, compares the signal to background intensity ratio, and analyses the variation of the intensity maxima within the narrowband emission. Corresponding physical interpretations on the plasma properties along the ray path will be addressed.

ON THE DIFFERENT RATIO OF LINEAR TO CIRCULAR POLARIZATION IN DIFFERENT SOURCES OF THE JOVIAN DECAMETRIC RADIO EMISSION

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We consider the nature of the difference of decametric radio emission ellipticity from B and A sources, as well as the difference between other sources. According to our view the ellipticity of decametric radio emission is fully defined by the magnetospheric plasma density distribution in the interaction region of jovian magnetosphere, i.e. in the region of the magnetosphere where effective linear mode coupling takes place for a given emission storm. Taking into consideration the model of the planetary magnetic field, which has significant variations of the field and the lack of the polar symmetry due to presence of magnetic multipoles, we show that the interaction regions for B and A sources are at different distance from the planet. The magnetospheric plasma density is differ in these regions due to radial inhomogeneity of the magnetosphere that results in different polarization ellipticity of observed emission from different sources. We discuss a possibility of magnetospheric plasma monitoring due to observations of polarization ellipticity of the decametric radio emission, as well.

RADIO EMISSION EVENTS ACCOMPANING CORONAL MASS EJECTION

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Analysis of the electromagnetic radiation connected with CME is of considerable interest both for understanding the nature of CME and their relation to solar flares.

In this report we discuss some new results concerning the microwave processes occuring during time intervals before the flash phase of a flare (precursors) and Coronal Mass Ejections (CMEs).

The observational samples illustrated the connection between the precursors and CMEs are presented. It likes probably to suggest the physical model of the microwave precursors phenomena on the base of CME arch.

THE CASSINI DUST EXPERIMENT

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The Cosmic Dust Analyser (CDA) was launched onboard CASSINI in October 1997. This instrument can detect and analyse interplanetary, interstellar, Jovian and Saturn dust. With its sensitive area of 0.1 m^2, fluxes as low as 1 impact/month can be detected. The measurement of the dust characteristics mass (10-15 - 10-9 g), electric charge (10e-15 - 10e- 12 C), chemical composition (mass resolution 20-50) and speed (1-100 km/s) is accomplished by using impact ionisation. A High Rate Detector (HRD) is used to detect high impact rates. The instrument capabilities and the scientific goals are presented.

IO-CONTROLLED DECAMETER ARCS AND IO-JUPITER INTERACTION

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The sweeping of the satellite Io by Jupiter's magnetic field results in an electrodynamic circuit, approximately fixed in Io's frame, revealed by UV and IR spots at the footprints of Io's flux tube (IFT) as well as prominent decameter radio arcs. We analyze the frequency-time shape of nine of these "Io-arcs", detected over their full frequency extent in joint Nancay and Wind data, and corresponding to four observation geometries (A,B,C and D). We compute the radio beaming angle as a function of frequency and lag of the radio-emitting flux tube(s) relative to the IFT. No assumption is made on the radio source location or beaming. We find northern (resp. southern) sources for A and B arcs (resp. C and D). The shape of all Io-arcs is consistent with origin from a single flux tube (in Io's frame), shifted by 10! (in the south) to 20! (north) with respect to the IFT. This lag must be accumulated before Io's magnetic perturbation reaches high latitudes. Radio emission is beamed in a hollow cone of average aperture 75! and thickness 1!. Arc shapes are fully determined by the geometry of observation. Radio fringes preceding the main Io-B arcs are well explained by multiple reflections of the magnetic perturbation between Jupiter's ionosphere and Io's torus. The weak trailing part of Io-B arcs may be accounted for through double-beaming of the radio emission or a frequency- dependent lag of the corresponding radio source. The latter explanation suggests an emission scenario in which electron acceleration "leaks" from the magnetic perturbation on its way to Jupiter. Magnetic field models are compared and evaluated in the analysis.

PS7 Laboratory studies and observations on dust, ices and organics in the solar system

Convener: Ehrenfreund, P.
Co-Convener: Kochan, H.

SIMULATIONS OF THE MARTIAN SPECTRAL RADIANCE IN THE PRESENCE OF ATMOSPHERIC DUST

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The interest towards Mars is nowadays renewed as various satellites, already launched or foreseen for the future, will visit this planet, providing a new wealth of data. In particular, infrared spectroscopic observations need a parallel modelling effort for a proper interpretration of observations. The goal of our modelling is to evaluate the influence of a non negligible fraction of dust particles on intensity and profile of atmospheric Martian spectra. The joint effects of the atmosphere and the surface materials have been also accounted for. For the modelling, a version of the MODTRAN code, expressly modified for application to the Mars environment, has been used. To represent the materials forming dust dispersed in the atmosphere and on surface, we have considered montmorillonite and palagonite. Indices of refraction (n and k) and reflectance of these materials measured in the laboratory have been used. The obtained results can have important effects on the interpretation of infrared spectra that instruments such as TES (Thermal Emission Spectrometer) on board the Mars Global Surveyor and PFS in Mars Express mission.

Presentation of chemical comet model.

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Cores of comets is primary the material consisting of frozen flying mixture hydrides (basically - a methane, a silane) and hydroxides (basically - brusite). External shell of core is formed in accordance with scheme described in [1] when a comet encounter with the Sun. Reactions of oxidation silane probably commit on surfaces of particles brusite, and it is possible with dehydratation of them. Water appear here. Of energy standing out in processes of these reactions sufficiently for forming the magnesium silicates only in thin layer of chemical reactor. Below they is absent, but there are water, brusite, silane. Possible in following cycle of rapprochement with the Sun will here be renewed chemical activity of comet and the mantle is product of it. In the course of time, volume of core is decreased, but volume of mantle is being enlarged. Here does not occur of the essential change of mineral component in contrast with the external shell of the core. But of water in the mantle is already not. And probably water has been connected of serpentinites in the external shell of core. Energy is being transmitted in the mantle together with the hydrogen from the chemical reactor. But it is sufficiently only for transmutation in the mineral structure of mantle of limited hydrocarbons into unlimited hydrocarbons of ethylene and diene rows. Further transformations of a hydrocarbons and mineral part occur in the crust. The thickness of this layer is not great because solar radiation have a small efficient penetration depth. Round-robin and aromatic hydrocarbons are being formed here. The joins Mg2Si , being product of recovering the oxidized magnesial silicates by the flow of a hydrogen from the core help possibly at this processes. The other product - water is lost by the comet. Certainly, its surface is renovated under the action of various causes up to destroying at the clashes with other cosmic bodies and of spraying its material in the explosive oxidation reactions of methane and silane. It is possible as well destruction of comet spontaneously when defensive layer between the core and area of chemical reactor is thin and, consequently, comets - a source of hydrocarbons of the Solar system.

NEW MOLECULAR SPECIES IN COMET HALE-BOPP

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Observations of the remarkable comet C/1995 O1 (Hale-Bopp) brought new insights on the composition of cometary ices. We present here the results obtained at the Institut de Radioastronomie Millimétrique (IRAM) telescopes and Caltech Submillimeter Observatory. They resulted in the first detection of HC_3N, NH_2CHO, $HCOOCH_3$, SO, SO_2 in a comet. HDO and $H^{13}CN$ were detected. HNCO and OCS, marginally seen in C/1996 B2 Hyakutake, were confirmed. These observations, together with observations of HNC and CH_3CN and of more "classical" species CO, HCN, CH_3OH, H_2CO, CS and H_2S, permit us to make an extensive inventory of the composition of the coma of comet Hale-Bopp. In addition, stringent upper limits on the abundances of a number of species of peculiar interest were obtained. A comparison with abundances found in interstellar hot cores believed to reflect the composition of interstellar grains is presented and discussed.

Laboratory Spectrophotometry of Analog Materials for Studies of Solid Planetary Surfaces.

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Measurements of laboratory reflectance and emittance spectra of analog materials are necessary for evaluation of remote sensed VIS/IR data obtained from planetary objects on board of space missions. The spectral and photometric properties of solid planetary surfaces depend on their geochemical composition, on the texture and morphology of the surface material and on the viewing and illumination geometry. Laboratory measurements of the reflectance in the visible and near infrared range and of the emittance in the mid infrared support the surface composition analysis and the extraction of textural and physical parameters for planetary surfaces. The DLR Spectrophotometry-Laboratory (SPL) combines facilities for the spectral and photometric studies consisting of a Fourier Transform Spectrometer analyzing the biconical reflectance and the emittance (Spectral-Laboratory, SL) in the VIS/NIR/MIR range and of the DLR-Gonio-Photometry-Laboratory (GPL) for measurements of the bidirectional reflectance in the VIS/NIR region. This work presents the DLR SPL. It summarizes results of the spectrophotometric analysis of different analog materials and discusses their implications for the evaluation of remote sensed data.

S.E.M.A.Ph.Or.E COMETAIRE, A TOOL FOR THE STUDY OF THE PHOTOCHEMICAL DECOMPOSTION OF PROBABLE COMETARY LARGE ORGANIC MOLECULES

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S.E.M.A.PH.OR.E COMETAIRE means in French : Simulations Experimentales et Modélisation Appliquées aux PHénomènes ORganiques dans les Environnements COMETAIRES (Experimental Simulations and Modeling related to Organic Phenomena in Cometary Environments). The aim of this work is to study the chemical pathways that lead to the decomposition of the organic molecules when they are ejected from the nucleus of a comet to its coma, as it is warmed by the sun. There is no direct or clear indication of the composition of comet nucleus, but the coma and its tail has been studied by in-situ and ground based observations. It could be very interesting to establish correlations between the nuclei's composition and what we can detect in the Coma. This study has three direct applications : a better understanding of the nuclear composition from large parent molecules, data for studying extended sources of H_2CO, CO and other daughter molecules, and it should help to link information from the lander and from the orbiter of the Rosetta mission. The first results which concern the irradiation of Polyoxymethylene (H_2CO polymer) and other compounds of cometary and exobiological interest, at 122 (Lyman á) and 147 nm, will be presented.

OBSERVATIONS AND LABORATORY STUDIES OF INTERSTELLAR AND COMETARY ICES: AN ISO VIEW

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ISO (Infrared Space Observatory) allows to study for the first time the complete inventory of interstellar ices over the entire spectrum between 2.5-45 μm. First ISO data showed the ubiquitous presence of ices in dense clouds which were never seen before, such as carbondioxide and methane ice and provided new insights into the gas to solid ratio of many interstellar molecules. ISO spectra of interstellar gas and dust in comparison with laboratory results and theoretical models constrain gas/grain interactions, temperature and irradiation conditions towards star-forming regions, and consequently their evolution. Well established abundances of interstellar molecules also guide the interpretation of past and future cometary observations. The recent ISO observations of interstellar ices reveal that the abundances of many ices measured towards embedded protostars are consistent with current cometary observations, indicating that interstellar ices may have been incorporated unaltered into comets. We present recent laboratory observations on ices in comparison with ISO observations and discuss their implications for comets.

OBSERVATIONS OF COMET HALE-BOPP: PHYSICAL PROPERTIES AND CHEMICAL COMPOSITION OF DUST GRAINS

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A review of completed and current photometric, spectroscopic and polarimetric observations of Comet Hale-Bopp is presented with the stress made on observations performed in FSU countries. Polarimetric behaviour of the cometary structures for various dates and moments of time is analysed in detail. Photographic observations made with 26-inch telescope of Pulkovo observatory in March and April, 1997 have shown an arm-spiral and shell structure inside the Comet's head. The physical parameters and chemical composition of cometary dust structures are derived. We consider the origin of separate Natrium tail of the Comet as the one produced by large molecular clusters evaporated from the nucleus. The place of Comet Hale-Bopp origin in the Solar System is also discussed.

MATRIX ISOLATION SPECTROSCOPY STUDY OF IRON REACTIVITY TOWARDS PAHs.

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The polycyclic aromatic hydrocarbons (PAHs) are thought to be responsible for the unidentified infrared (UIR) emission coming from the interstellar medium (ISM). An other question to be answered is the iron depletion in the ISM. Some authors have then proposed that a part of the missing iron could be "hindered" in organometallic complexes such as $Fe_n(PAH)_m$. A convenient route to the preparation of such species and their identification by means of spectroscopy may be obtained through the co-condensation reaction of metal atoms or aggregates with PAHs in matrices at cryogenic temperature (12K). Our FTIR investigations in argon matrices have shown that such $Fe_n(PAH)_m$ neutral complexes may be formed in low temperature dense regions of the ISM. With pyrene, three species with different metal-ligand bonding are observed. Results obtained with coronene suggest that the iron dimer Fe_2 is more reactive than the atom to form π-complexes.

OBSERVATIONS ON DUST, WATER AND ORGANICS PRESENT IN "GIANT" ANTARCTIC MICROMETEORITES

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Large micrometeorites recovered from Antarctic ice in the 25-400 μm size range include a major component made of complex aggregates of fine-grained dust consisting of anhydrous and hydrous minerals, as well as carbonaceous matter. These micrometeorites represent by far the dominant extraterrestrial material accreted by the Earth today . They are chemically and mineralogically related to the relatively rare group of CM carbonaceous chondrites (about 1% of the meteorite falls). However, beside similarities including the isotopic composition of their constituent water, and the mineralogical and isotopic compositions of their refractory inclusions (CAIs), they also show major differences to this group of meteorites, such as a severe depletion in chondrules . Micrometeorites represent a new class of solar system material, which is not represented in the meteorite collections . With the reasonable assumption that meteorites and micrometeorites originate from asteroids and comets, respectively, the comparison of their high temperature phases (CAIs and chondrules) unexpectedly leads to new constraints on the formation of the solar system, that support a scenario proposed for chondrite formation by Frank Shu .

FORMATION OF ORGANIC MOLECULES DURING IMPACTS.

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The evolution of organic matter from abiogenic species to complex molecules is a fundamental problem of the Earth's evolution. Various experiments shows that the formation of organic molecules from simple C-, H-, N-, containing species proceeds rather effectively under reduced conditions during the action of different energy sources (electric discharges, heating, shock waves, radiation, etc.). The formation of organic molecules during impact processes has special interest since impacts were the most powerful energy source during accretion period and still play an important role in planetary evolution. Laboratory simulation of impact vaporization process and investigation of accompanying chemistry shows the presence of rather complex organic molecules in the resulted products. High-temperature processes during impacts of silicates proceed under the domination of free molecular and atomic oxygen what is vital for the formation of organics. Analyses of resulted products shows the formation of both oxidized and reduced species during impact simulated vaporization. Thermodynamic calculations speaks not in favor of gas phase reactions for the production of organic molecules. Heterogeneous type of reactions on the surfaces of condensed particles can be more reasonable.

THERMAL EVOLUTION OF AMORPHOUS MAGNESIUM SILICATE SMOKES

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Highly amorphous silicate grains which form in the outflows of mass losing stars or in the ISM must undergo some degree of thermal processing to form more ordered materials. Amorphous magnesium silicate smokes were prepared in the laboratory by vapor phase condensation and annealed in vacuum. The samples were monitored by IR spectroscopy as a function of annealing time and temperature, focusing on the development of the 10 micron silicate feature. Thermal evolution of the initially chaotic condensates led to the appearance of peaks at both 9.8 microns, similar to the feature observed for silicate grains in circumstellar outflows and in the ISM, and 11 microns, indicative of "crystalline" olivine. The dual maxima 10 micron feature is a natural consequence of the thermal evolution of the amorphous condensate, rather than a mixture of amorphous and "crystalline" materials. We are investigating how the appearance and duration of the dual maxima feature is effected by the magnesium concentration and the morphology of the initial condensate as well as the annealing history of the grains.

THEORETICAL PHOTOPOLARIMETRIC RESPONSES OF FRACTAL AGGREGATES AND THE CODAG/ESA EXPERIMENT

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The solar light scattered by dust particles in the Solar System depends upon the physical properties of the dust. The particles are irregular aggregates whose scattering properties cannot be adequately described by simple models. However, the CODAG rocket experiment (to be launched during the spring 98) should provide laboratory results in a near future. Goals of this experiment are to study aggregation processes in microgravity conditions in the basic case where constituents of the particules (also called monomers) have the same size and are initially individual spheres, and to carry out photopolarimetric measurements in order to infer clues about properties of the scattered solar light.We expect a Ballistic Cluster-Cluster process, which correspond to a fractal dimension close to 2.
In this context, it has been necessary to explore theoretical photopolarimetric responses of this kind of aggregates. They allow experimental choices to be made and results to be obtained, in order to understand the experimental data. Using a fractal description of aggregates and Draine's code based on the Discret Dipole Approximation, we analyse influences of some parameters of those particules : (1) shape versus the fractal dimension which depends on aggregation processes. (2) complex refractive index. (3) size parameter of particule, which depends on the size and number of monomers in the aggregate. Such results will be of use as well in the case of CODAG experiment as in the case of more sophisticated future experiments.
CODAG is funded by CNES and ESA.

MODELLING OF ATMOSPHERIC DUST EMISSION AND SURFACE REFLECTANCE OF MARS APPLYING A RADIATIVE TRANSFER SIMULATION IN THE 2.0 AND 2.7 μm CO_2 BANDS

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Synthetic infrared radiation spectra of Mars which can be measured by an orbiting Planetary Fourier Spectrometer (PFS) have been calculated in the spectral region from 1 to 50 μm. A radiative transfer simulation technique was applied taking into consideration absorption, emission and multiple scattering by molecular (CO_2, H_2O, CO) and particulate (palagonite, carbonate, ice) species. It is shown that the radiation contributions from atmospheric dust emission and surface reflectance can be separated in the region of the CO_2 bands at 2.0 and 2.7 μm, respectively. Quantitative results of an aerosol retrieval procedure are discussed.

ICE GRAINS IN COMETS: LABORATORY AND NUMERICAL MODELLING

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The ice grains ejection from surface of pure water ice and from surface of water ice with carbon dioxide admixture was determined in our laboratory experiments where a cometary nucleus models were irradiated by light. The temperature, the sublimation rate, the life time, and the effective acceleration of the spherical ice grains for different heliocentric distances were calculated and the possibility of ice particles existence in cometary head and dust tail was studied. The 10-100 microns ice particles may exist in comet atmosphere during a long time, but they can not form a dust tail at r < 2 A. U. because their effective acceleration is almost egual zero. The ice particles <10 microns can form a dust tail on r > 3 A. U.

THE GENERAL PROPERTIES AND FORMATION CAUSE OF THE DUST BANDS IN II TYPE COMETARY TAILS.

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Formation conditions and properties of the dust bands in II type tails of comets 1910 I, 1957 V, 1962 III, 1965 VIII, and 1976 VI has been studied. The following general properties of the dust bands in these comets and their formation cause were determined: 1. The dust bund's maximal value of the effective acceleration decrease when its age increase, i.e. a cloud of submicron-micron dust particles in comet tails fall to pieces more rapidly than the cloud of larger particles (micron and more sizes). 2. The axis of the dust bands do not intersect the cometary nucleus and is located between nucleus and the Sun. The ages of different parts of the dust bands are different. 3. The matter of dust bands was ejected from nucleus in perihelion region of comet's orbit. 4. The most possibility cause of dust bands formation is nucleus splitting. The number of bands in the cometary tail is possible indicator of number of relatively big fragments of the nucleus after its splitting. 5. The nucleus of comets with dust bands of the II type tail present a compact swarm of ice-dust blocks.

ABOUT MODELLING OF THE IR SPECTRAL FEATURES OF THE ICE DUST PARTICLES

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Recent progress in the laboratory measurements of the refractive indexes of the ice mixtures has lead to improved models of dust grains that are widely used in the interpretations of the IR spectral features in the spectra of different young stars and objects in the Solar System. This work is an examination of the feasibility of the laboratory measured refractive indexes of different ice mixtures to the interpretation of the infrared features of the real interstellar and interplanetary dust particles. We present here results for the dust particles of different size, structure, topology, porosity, shape, electric charge and chemical composition.

THE NOVEMBER 1998/99 LEONID METEOR SHOWER UPDATE

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Preparations are underway for airborne, space borne, and ground-based observing campaigns to explore the November 1998 (and November 1999) Leonid returns. These represent our only chance in a lifetime to anticipate a meteor storm. The high fluxes make it possible to use instrumental techniques that normally suffer from low detection rates. Because of the brief but significant enhancement of influx, the dynamics of meteoric dust in the atmosphere can be followed. Moreover, these are not normal meteors. They consist of relatively fresh ejecta that still contain information about the ejection process, are relatively unexposed, and are part of a cometary dust trail. Indeed, observations of a meteor storm provide unique data for the study of cometary dust trails. I will review the results of space borne, and ground-based observing efforts during the previous 1997 Leonid return. I will give an update of the prospects for high Leonid rates in the next 1998 and 1999 returns. In addition, I will outline the observing strategy for an international Leonid multi-instrument aircraft campaign and discuss validation efforts that have been made thus far.

DEVELOPMENT OF SMALL SAMPLING SYSTEMS FOR THE INVESTIGATION OF PLANETARY SURFACES

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The development of drill bits and the breadboard model of a small sample acquisition and distribution tool (SSA/DT) for cometary, Lunar or even Martian application as result of an ESA technology-study, is presented. The final tests were performed under normal and space simulated environmental conditions with simulated cometary, Lunar or even Martian sample material. The presentation will also deal with the "mobile penetrometer", a small cylindrical body, for deeper sub-surface investigation. This penetrometer, 2cm in diameter and around 32cm in length was also developed for space mission applications.
The intrusion of this penetrometer into cometary analogous ice was successfully tested at liquid nitrogen temperature (77K) and vacuum in the Planetary Simulation Facility of DLR Köln.

LOW-VELOCITY IMPACT STUDIES FOR THE ROSETTA MISSION

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The Rosetta Spacecraft, to be launched in 2003, will rendezvous with comet P/Wirtanen in 2011 and accompany it for at least one year in close distance on the order of several cometary radii. It is expected that the dust ejected from the comet will impact the spacecraft and either stick to the surfaces exposed to cometary dust or change their properties. To access the influence of the particles on the spacecraft, we perform impact experiments with a coil accelerator at the Fachbereich Raumfahrttechnik of the TU Munich. Projectile size ranges are 0.1 mm to 2 mm in diameter, projectile velocities are between about 20 and 200 m/s. Projectile materials are glass, ice, and fluffy agglomerates, target materials are aluminum, MLI, and optical materials. This presentation will give first results of these experiments.

HYDROCARBON SYNTHESIS IN COMETARY GRAINS

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Chondritic porous interplanetary dust particles (CP IDPs) collected in the stratosphere are traditionally associated with cometary dust. They contain FeNi carbides and carbonaceous rims on grains. We have carried out laboratory studies in order to simulate the interaction between FeNi metal particles and a nebular-type gas phase under experimental conditions presumed for IDP formation. Carbide formation is experimentally found to be accompanied by the simultaneous synthesis of organic compounds and non-graphitic carbon deposition. Both saturated and insaturated hydrocarbons and sulfur-containing molecules are formed. These results strongly support the idea that gas-solid reactions in the solar nebula represent a plausible scenario for the formation of organic compounds as well as carbonaceous materials in comets. Carbon deposits and carbides are similar in nature to those reported in CP IDPs. In order to test that organic molecules in comets might be produced by such a mechanism, a more detailed knowledge of the chemical distribution of hydrocarbons in comets obtained by direct analysis -in order to avoid fractionation and transformation reactions of parent molecules- would be highly desirable. The Rosetta mission thus appears to be an excellent opportunity for this purpose, since it is intended to provide, for the first time, in situ analysis of organic pristine material in comets.

DIELECTRIC PROPERTIES OF WATER-AMMONIA ICE MIXTURES

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I report preliminary measurements of the complex permittivity of frozen water-ammonia solutions (0-30% NH_3) at liquid nitrogen temperatures (77K). A literature search has revealed to date only measurements of pure ice at these temperatures, although Thompson and Squyres (*Icarus*,**86** : 336-354) have made theoretical predictions. Measurements were made at 0.3-1 MHz using a HP 5371 network analyzer (complex permittivity) and near-DC conditions (real part only) using a capacitance meter. . Ammonia-rich solutions, which are the most likely cryolava composition in the Saturnian and Uranian systems (owing to the freezing point depression by ammonia - the peritectic composition of $\sim$ 30% NH_3 has a freezing point of 176K), have significantly higher dielectric constants and loss tangents than pure water ice. These results have application to interpretation of the planned observations of the Saturnian satellites by the radar instrument aboard Cassini and may in part explain the low radar cross section and polarization behaviour of Titan, which resembles an icy surface in the near-IR, yet has the radar signature of a rocky body (Lorenz and Lunine, *Planet. Space Sci.* **45** : 981-992).

NATURE OF ICE AND NON-ICE CONSTITUENTS OF THE SURFACES OF THE ICY GALILEAN SATELLITES

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The Near Infrared Mapping Spectrometer (NIMS) on the Galileo Mission has produced reflectance spectra and spectral maps for the spectral range 0.7 to 5.2 Âm with up to 408 spectral channels for hemispheric regions at 10s-100s km resolution and for smaller regions at > 1 km resolution. We present an update on the recent discovery of CO2, SO2, CN and CH in the surface materials of Callisto and Ganymede using the NIMS reflectance spectra Interpretation of data from the first three orbits suggested the presence of these materials (McCord, et al., Science, 278, 271-275, 1997). Subsequent analysis confirms these spectral signatures and better-illustrates the correlation of the distribution of these materials on the icy satellites with features revealed by the SSI imaging system. Further, these spectral signatures are noted to be similar to those seen in ISO spectra of interstellar ices (Whitten, et al., 1997). Analysis of the ice spectra in the 3-5 Âm region suggests that the ice is mostly crystalline on Callisto and Ganymede, but mostly of disordered crystal structure on Europa. Hydrated minerals were known to compose significant amounts of the surface materials of Callisto, Ganymede and Europa from groundbased telescopic observations, but their identities were not determined. Our recent analysis of NIMS Europa spectra indicates that heavily hydrated salt minerals, probably magnesium sulfates, are a significant constituents of the darker areas. These materials are usually formed by evaporation of brines, which suggests that liquid water rich in dissolved salts were ejected recently onto the surface of Europa, perhaps from a liquid ocean beneath an ice crust.

SPECTRAL ESTIMATIONS OF ASTEROID MINERAL COMPOSITIONS: EFFECTS OF SPECTRALLY NEUTRAL COMPONENTS

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Olivines and pyroxenes are important constituents of the small bodies of the Solar System, such as asteroids, comets, the Moon. The laboratory studies of meteorites and spectrophotometric observations of the small bodies show that in many assemblages both of these minerals are present. In particular, the near-infrared reflectance spectra of S-type asteroids display absorption features attributable to both olivine and pyroxene, although these absorption signatures are somewhat subdues due to the presence of other components, e.g., metal iron, sulfides. Since these additional components are lacking of absorption bands in the near-infrared, they have been neglected when interpreting remote sensing data. For example, the interpretation technique developed by Cloutis *et al.* (1986) for binary olivine-orthopyroxene mixtures is widely used to estimate relative proportions of these two minerals in multi-component asteroid assemblages, since all other components are considered as spectrally neutral and hence should not affect the ratio of intensities of orthopyroxene and olivine absorption features. Our laboratory spectral reflectance studies of powdered ternary mixtures of olivine, orthopyroxene and "spectrally neutral" materials (sulfide, plagioclase, glasses) demonstrate, that a complete disregard of neutral components may result in the underestimation of orthopyroxene content in the regoliths.

ISO AND GROUND-BASED OBSERVATIONS OF TITAN IN NEAR-IR WINDOWS AT 2.7 AND 5 MICRONS

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It has been known for some time that it is possible to sense the lower atmosphere and surface of Titan at selected wavelengths in the near - IR known as windows. We have made new observations through two of these windows, using ISO and the United Kingdom Infrared Telescope. We find that the well-known hemispheric asymmetry disappears at wavelengths, providing a new constraint on the possible composition of surface materials. The use of the 5 micron window to determine the atmospheric value of CO and the 2.7 micron window to search for signs of cloud systems will be discussed.

INFRARED REFLECTANCE SPECTRA OF MARTIAN ANALOGUES

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Present and future space missions to Mars include spectroscopic observations in the infrared from which an important improvement in our knowledge about atmosphere and surface composition is expected. A fruitful exploiting of the wealth of data that in situ observations will provide cannot be performed without a careful characterisation of materials in the laboratory. In particular, it is rather important to study the optical properties of compounds which are considered candidate to simulate both the surface regolith and the atmospheric dust. Materials considered in the present work are calcite, montmorrillonite, palagonite and andesite. Raw materials have been ground and selected in different calibrated size ranges in order to correlate spectral observations with morphology. Spectral measurement have been performed on the samples both in specular and in diffuse reflectance. Transmittance measurements have been also obtained. By applying a Lorentz oscillator model the optical constants have been retrieved from specular reflectance data. The set of spectroscopic results forms a reference frame useful to obtain quantitative information from Mars observations once used in appropriate radiation transfer models.

RADAR SUBSURFACE SOUNDING IN THE MARS EXPRESS 2003 MISSION

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The paper deals with the E.M. modeling of Mars surface and subsurface, as observed by an orbital radar sounder, like the Subsurface Sounding Radar Altimeter (S.S.R.A), which has been indicated as a very important feature to be offered by the payload of the ESA Mars Express 2003 mission. The main objective of Mars subsurface sounding is the determination of the presence of H2O, either liquid or solid, in the martian regolith: this will be accomplished by mapping the presence of subsurface discontinuities over the surface of the planet, and studying the correlation of the discontinuities with depth, latitude, surface topography and local geologic formations. Since the radar sounder is expected to work down to depths of some 5 Km, and making reasonable assumptions on the materials which constitute the interior of the planet, a very low sounding frequency must be used in order to minimize the absorption due to the lossy medium between the surface and subsurface layers. As a matter of fact a preliminary analysis, shortly discussed in the paper, has led to frequencies of a few MHz. In order to optimize the system parameters and evaluate the performance, in terms of detection of the subsurface layer, surface scattering models valid for such low frequencies must be carefully studied: a two scale surface model will be proposed in the paper for the application in the Mars Express 2003 radar sounder design. By means of this model it will be possible to evaluate the surface to subsurface power ratio as the sounding depth increases, and to state the maximum depth at which the subsurface echo is still detectable. A description of the models used for surface and subsurface scattering prediction, as well as first results on the expected performance under various operative conditions will be included in the paper.

Possibility of relict organic pigments detection on Mars surface from the Earth, Orbiter or Lander

[redacted]
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[redacted] pigment detection in Mars and other planets surface by using of the passive remote technique. It is well known that the organic pigments and components has a strong fluorescence in visible spectrum under the laser and solar ultraviolet exitation. The principal finding was that ancient-relict organic pigments which were conserved inside the crystals of the surface minerals demonstrated the strong fluorescence after heating under 650°C for 2 hours. The success of the Earth spaceborne radiance-ratio method for estimating oceanic chlorophyll concetration permit studies of the variability of Mars surface color spectral radiance by using of solar-induced spectra. Fortunately the low Martian atmospheric density during the clear phase avoids the problem of the sky radiance variations and contribution due to Rayleigh scatter will be neglected. In comparision with Earth the low ozone concentration produced a strong effect to Mars surface and exitation fluorescence spectrum by hard ultraviolet (down 300nm). So, band combinations and visible-red (near 700nm) ratio for normalizing to the surface albedo showed considerable promise for satisfactory relict organic pigments detection and 2-D mapping by using color Mars images from the Earth, Orbiter or Lander from the old and future missions. The Moon images may be used for testing.

Lidar technique for organic pigmeats determination in planetary surface

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The need to determine of the organic (relict) components on Mars/Earth surface over large areas has led to recent developments of the Lidar remote technique from the moving platforms: helicopter or lander. The attempt of the plasma creation by laser beam on the Phobos surface (LIMA-D) and Mars Orbiter Laser Altimeter (MOLA-92) indicates on possibility to use Lidar technique from the satellite-orbiter too. We used fluorescence Lidar based on the third (355nm) harmonic of the Nd^{3+}:YAG pulsed laser and studied many samples of soils, minerals, leafs and sea-water. The fluorescence spectra in the blue-green-red range were recorded by cooling CCD array with the gating light intensifier. Green fluorescence may be ascribed to such organic components as polynuclear hydroxyquinone of microfugal origin; orange and red band - phycocyanin and phycoerythrin from blue-green alga and red emission from chlorophyl-type pigments. After heating of the soil samples (650°C, 2 hours) the fluorescence spectra changed dramatically and corresponds to the spectra of the background mineral. The difference of this spectra is proportional to the moving organic matter inside the soil and correlates with its productivity. We observed the strong difference between fluorescence spectra of the ancient fern-like footprint on the stone and clear stone surface. It permits us to detect a relict organic pigments in the Mars surface by lidar remote technique from the orbiter/lander.

THE BEAGLE LANDER FOR MARS EXPRESS

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The E.S.A Mars Express Mission to be launched in mid 2003 is to carry a variety of orbiting and landing experiments. One of the landers, named Beagle 2, is to be primarily dedicated to the investigation of whether Mars once supported life and to establish the nature of environmental conditions below the surface. The approximately 90kg space craft will carry a mini rover equipped with a sub-surface mole sampling device with a view to retrieving specimens which can be analysed for element abundance, isotopic composition, mineralogy and oxidation state. Any surviving organic matter will be characterised by appropriate technologies and the presence of water in sheltered localities will be investigated. The analysis systems will be capable of considering the make up of the atmosphere, especially in respect of trace constituents and will evaluate how this changes with time during the mission.
The Beagle 2 Team is made up of scientists from Germany, France, Holland and UK - whose help is gratefully acknowledged.

LABORATORY SIMULATIONS OF SURFACE REACTIONS OCCURRING IN SPACE

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Sophisticated chemical models have been built by theoretical astrochemists for interstellar clouds in both static and dinamically evolving stages. Among the other input parameters to be used in such models, very relevant are data relative to the reaction rates between considered species. Whenever possible, of course, experimental results have to be preferred. This has, in fact, been usually done for gas phase reactions and recently also in dense clouds for UV photon induced reactions in icy mantles. Unfortunately up to now laboratory data on chemical reactions occurring on the surface of dust grains, that in the extreme physical conditions encountered in interstellar clouds may act as catalysts, have not been included because of the almost total absence (lasting until not too long ago) of experimental simulations, performed in conditions and on surfaces that closely resemble interstellar ones. These reactions are by the way of not negligible importance; they may have, in fact, great impact on the chemical evolution of clouds, or at least on timescales, as the case of molecular hydrogen formation shows clearly. In this paper are reviewed experimental efforts and results obtained in this rapidly evolving field.

ICES IN THE SOLAR SYSTEM

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Moderately-to-highly volatile molecules such as H_2O, NH_3, SO_2, CO_2, CH_4, CO, and N_2 are present as ices in the solar system and represent a large fraction of its mass. Recent ground-based investigations and space missions (Voyagers, Giotto, Galileo, ISO) have provided a wealth of new and high quality information on the composition, surface morphology and physical properties of solar system planetary surfaces. Future space missions (Cassini-Huygens, Rosetta, Mars missions, Fast Pluto Flyby, ...) will further improve the spectral and spatial resolution of these data. The surface and atmospheric particles composition and properties of the icy objects (Mars, some satellites of Jupiter, Saturn and Uranus, Triton, Pluto and Charon, the outer planets' rings, and comets) being largely deduced from UV-to-IR spectroscopy and photometry, we will first provide an overview of the existing observations. We will then review some recent laboratory measurements of the spectroscopic properties of ices as well as new numerical models developed for the analysis of high resolution spectra and spectro-images. Finally we will illustrate the use of these data and models and their potentiality with the interpretations of several recent observations.

CO/CO_2 MOLECULAR NUMBER RATIO PRODUCED BY ION IRRADIATION OF ICES

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Ion irradiation of ice mixtures produces several effects among which the production of other species not present in the original target. We have studied, by infrared absorption spectroscopy, the formation of carbon mono (CO) and di-oxide (CO_2) after ion irradiation of astrophysically relevant ice mixtures. Non-polar mixtures containing CO, N_2, O_2, and CO_2 have been irradiated as well as polar mixtures containing H_2O, CH_3OH, CH_4, and NH_3. We have evaluated the molecular number ratio CO/CO_2 as a function of the irradiated mixture, irradiation dose and temperature. The comparison of the laboratory results with the finding from ISO observations would be very usefull to understand the formation process and evolutive scenario of CO and CO_2 frozen on interstellar ice mantles.

MEASUREMENTS OF METEOROIDS AND DEBRIS FROM GEOSTATIONARY ORBIT BY THE GORID EXPERIMENT

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A full year of data has now been collected in the geostationary orbit by the meteoroid and debris detector GORID on the Russian Express II satellite. A large number of events has been registered and analysis of the data is proceeding. Preliminary analysis has shown a number of occasions with clustered events that are very likely to be real particle impacts. Some of these seem to occur at n:m resonance, where n>1 is the number of full orbits of the satellite and m is the number of orbits of the clustered particles. This indicates that the clusters are fairly recent. At other times/positions events are registered at every orbit (n=3D1). These events could be related to particles that have been orbiting the earth for a longer time. Another interesting but not yet fully explained observation is the high electrical negative charge that is found on many of the particles detected during local night time. These particles would need to be fairly large and slow to give results like these if one considers the plasma environment and the detector sensitivity.

NIR REFLECTANCE SPECTROSCOPY OF Ca- AND Fe-RICH CLINOPYROXENES: RELATIONSHIP BETWEEN SPECTRAL FEATURES AND CHEMISTRY

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Pyroxenes are ferromagnesian sillicate minerals which can be found in primary igneous rocks. They are abundant in the upper crust and on the surface of terrestrial planets as well as on asteroids and in most of the meteorites. Pyroxenes show a broad variety of ionic substitutes depending on the petrogeny. Therefore, the investigation of the chemistry and of the mineralogy of pyroxenes are not only essential in determining the genesis of the pyroxene bearing rocks but also important for the genesis of the upper planetary crust. Pyroxenes as major mineral phases in basaltic rocks on surfaces of terrestrial planets have spectral features in the 1 µm and 2 µm region of their NIR spectra due to the ferrous crystal field absorption. These bands are diagnostic for the mineralogical investigation by means of remote-sensed reflectance spectroscopy. The position of the absorption bands enables the spectroscopic distinction between orthorhombic and monoclinic pyroxenes and hence the evaluation of the Ca/Fe composition of the relevant pyroxene. However, for clinopyroxenes with a high abundance of iron and a high portion of calcium the spectra become more complex in the NIR region. This paper reports on the reflectance spectra of different sets of ferroaugite, salite and hedenbergite with different content of Ca and Fe and tempts to describe influence of the chemical composition on the spectral features. Such laboratory investigation of pyroxenes may help in discussing remote sensing-data of planetary surfaces, for instance of Mars.

GRAIN FORMATION IN EJECTA OF SUPER NOVA: THE EFFECT DUE TO THE RADIATION

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Formation of dust grains in the ejecta of supernovae was investigated on the basis of a theory of homogeneous nucleation and grain growth by Kozasa et al. (1989a,b, 1991). According to the comparison their results with the observed luminosity of SN 1987A, it is difficult to explain the observation without introducing some parameters which determine the condensation efficiency and the concentrations of grains in the ejecta. In the theory of nucleation adopted by them, the effect of radiation was not taken into account. In this study, we develop the nucleation theory taking into account the effect of the radiation and investigated the grain formation in the ejecta of supernovae. The time of the grain formation and the size of created grains strongly depend on the temperature structure and the thermal structure and evolution of the ejecta: the time of grain formation is retarded by the radiative field of supernovae. The nucleation theory taking into account the radiation would be useful to another astrophysical environments, e.g., stars with mass loss, protoplanetary nebula, and the vapor formed by collision between planetesimals.

NIR REFLECTANCE SPECTROSCOPY OF PYROXENES: FERROAUGITES; SALITES; HEDENBERGITES

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Pyroxenes are among the most ubiquitous minerals present on the surfaces of the terrestrial planets, most asteroids and meteorites. Because IR spectroscopic remote sensing is one of the most used techniques to investigate the compositional properties of planetary surfaces, it is important that the spectral properties of the main mineral phases be well understood. The NIR spectra of the pyroxenes are mainly characterized by the 1µm- and 2µm signatures. Their wavelength positions depend stronly on the chemical composition of these phases and is, on the whole, well known in the case of the ortho- and clinopyroxenes which are the most significant ones in planetary volcanics. However, moving to ferroaugitic, salitic, and hedenbergitic compositions the character of the spectra changes drastically. Thus, the 1µm signatures become more and more complex and the 2µm signatures diminish or disappear completely. It appears that there are „ferroaugitic", „salitic", „hedenbergitic" spectra which are different from each other. The reason for these spectroscopic differences might be caused, above all, by variable oxidation states of these pyroxenes and, therefore, by variable portions of ferrous and ferric iron.

POLARIMETRIC MEASUREMENTS OF SCATTERED LIGHT BY DUST GRAINS IN MICROGRAVITY CONDITIONS (PROGRA^2 EXPERIMENT)

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The PROGRA2 experiment was designed in 1994 to study the degree of polarization of the light scattered by irregular dust particles in microgravity conditions. This instrument has successfully flown on 8 parabolic flight campaigns, yielding 14 polarimetric phase functions of various samples for the first 7 campaigns (7 additionnal curves are expected for the last campaign). Certain physical properties of the grains are linked to specific parameters of these curves. Results from the May 97 campaign on the CNES A300 Airbus will be presented. A major improvment of the instrument was implemented during the last campaign with the introduction of a digital video camera system to follow the movement of the dust particles with a sufficient resolution, to determine whether single particles or aggregates are present, and to measure their number density. The influence on these polarimetric parameters of number density and size distribution for three sample types are our present goal.

PS8 Meteorites and cosmochemistry

Convener: Jagoutz, E.
Co-Convener: Robert, F.

ON THE SOLAR MODULATION OF COSMOGENIC RADIOISOTOPES IN METEORITES OVER THE LAST TWO CENTURIES

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Production of cosmogenic isotopes in meteorites depends on the galactic cosmic ray (GCR) flux, which is controlled by solar activity. The most suitable radionuclides in meteorites for the investigation on the heliospheric modulation of GCR for the 11 year solar cycle are ^{54}Mn and ^{22}Na. We measured in our Laboratory the γ - activity of three fresh fall meteorites during solar cycle 22 (1986-1996): Torino (1988) which contained the effects of the minimum of solar activity; Mbale (1992) containing the effects of the maximum; Fermo (1996) which has imprinted the effects of the decreasing phase. The difference from maxima to minima for both ^{54}Mn and ^{22}Na is ~20% as expected on the basis of model calculations. Cosmogenic ^{44}Ti is the only radionuclide in meteorites suited for inferring the century scale variation of the GCR and consequently the long term behaviour of the heliospheric magnetic field. We measured the ^{44}Ti activity of 13 chondrites which fell in the interval 1840-1996. The trend of ^{44}Ti, corrected for Fe+Ni target element abundances, agrees with the expected one, but the variations are 4 times higher than expected from the modulation deduced solely by sunspot numbers. The results obtained show a different behaviour of the heliosphere during prolonged solar quiet periods such as at the turn of this and of the past century.

EXCESS 53-Cr IN THE PRIMITIVE ACHONDRITE DIVNOE.

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The 53-Cr/52-Cr isotope ratios and Mn and Cr concentrations have been measured in two different types of chromites (coarse Chr-1 and fine grained Chr-2), in orthopyroxene (Opx) and in olivine (Ol). All studied samples show excesses of 53-Cr relative to the terrestrial value. The measured 53-Cr excess in Chr-1 of 0.48 =B1 0.06 epsilon units (eu) is the same as that in the present day bulk chondrites. Ol, with a high 55-Mn/52-Cr ratio of 29.2, shows within the uncertainties the same 53-Cr excess: 0.53 =B1 0.07 eu= . The 53-Cr excesses in Opx and Chr-2 are also the same (0.59 =B1 0.05 eu and 0.59 =B1 0.07 eu, respectively) but are slightly larger than those in Chr-1 and Ol. It is possible that Chr-1, Opx and Ol have been formed contemporaneously in an environment with a chondritic Mn/Cr ratio when 53-Mn was still alive. However, due to subsolidus Cr diffusion in an environment which was hot for a prolonged time, Ol inherited almost all its Cr from Chr-1. This assumption is supported by the fact (Petaev et al. (1994)) that olivine which is in contact with large chromite grains shows tremendous Cr zoning, with Cr content decreasing from the rim (0.7% Cr2O3) to essentially zero at the core. Chr-2 has a secondary origin: when all 53-Mn had decayed, it was exsolved from Opx, inheriting its Cr isotopic signature from Opx.

COSMOCHEMISTRY OF REDUCED SILICON IN THE SOLAR NEBULA AND PLANETARY CORES

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Silicon, a dominantly lithophile element, also occurs in the reduced state (Si^0) forming part of metallic FeNi alloys in meteorites and, most probably, terrestrial planetary cores. In meteorites, the presence of metallic silicon is commonly interpreted as the result of condensation under low-fO_2 conditions in the solar nebula. In planetary cores, silicon may have been added in substantial amounts to the sinking metal during core formation at temperatures not exceeding those typical of protoplanetary accretion, under solar-nebula fO_2 values. In this paper, a quantitative model and experimental results accounting for the distribution of metallic silicon in different environments are presented. Implications of these results suggest important local physical (total pressure) and chemical (oxygen fugacity) heterogeneities in the solar nebula, as well as a strong argument in favor of silicon being the dominant light element in the Earth's core.

THE CHEMICAL STATE OF CARBON IN THE MURCHISON METEORITE

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The distribution of 2p valence electrons of carbon was investigated for the carbonaceous chondrite (CM2) Murchison in situ (without extraction). Simultaneously, various carbon compounds were measured for comparison: graphite, diamond (including nano-diamond), fullerene and polymerized amorphous fullerene. Carbon Kα spectra were obtained with the x-ray spectrometer of the Institute of Inorganic Chemistry at Novosibirsk (energy resolution 0.4 eV).

The low-energy part of the carbon spectra for Murchison (271.0 - 277.0 eV) is identical to that of graphite, but the short-wave part (278.0 - 282.0 ev) is more intensive and has an intermediate position between fullerenes and graphite. The short-wave part is connected with transitions from π-levels.The high intensity of this part of the spectrum shows the presence of sp3-hybridisations for carbon in Murchison. The structure of the short-wave part is complicated and presents the superposition of two states of sp3 forms of carbon: diamond and fullerene. In general, carbon in Murchison is a mixture of sp2 and sp3 forms and a systematic investigation of the valence states of carbon for other carbonaceous meteorites can be useful for the study of carbon transformations during metamorphic processes.

CORE-RIM AND RIM-MATRIX RELATIONSHIPS IN INDIVIDUAL CHONDRULES AS INFERRED =46ROM THE Sm-Nd ISOTOPE DATA.

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Chondrules are believed to represent some of the most primitive material in the Solar System. Many aspects of the relationships between chondrules, matrix and rim are still unclear and are relevant to the origin of these major components. Numerous studies of individual chondrules have shown that trace element abundances can vary over a wide range from the chondrule's core to its rim and from the rim to the matrix. The purpose of the present study is to investigate separately, using the Sm-Nd system, the components of chondrules: the core and the rim, along with the matrix immediately surrounding the chondrule. In order to achieve this goal, we developed a special technique of chondrule abrasion, which allows one to separate and analyze the above components. Thus if the origin of matrix, rim and chondrule, can be cast in terms of a three component system, we could solve many enigmas. In order to test our equipment we processed one chondrule from Bjurb=F6le (L/LL4) chondrite. The initial mass of the chondrule was 16.32 mg= The isotopic composition of Nd varied drastically from the rim to the chondrule's core (eNd =3D - 3.7 and eNd =3D + 15.4, respectively). These results indicate that the new stepwise abrasion technique is very useful in investigating the composition of different parts of chondrules. The procedural blank is low, 0.8 pg for Nd and less than 0.2 pg for Sm.

PS8

FELSIC CONTINENTS OF MARS

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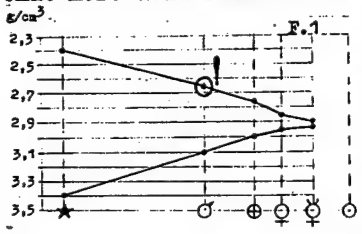
Light(not dense)continents-albitite,syenite,granite-were predicted as a consequence of the regular wave planetary tectonics at the XXII EGS Assembly(Ann.Geoph.,Suppl.III to v.15,pt.3, p.767).The Sojourner APX-spectrometer data(Internet;H.Wänke et al.,1997)prove existense of highly fractionated rich in Si,Al,K rocks similar to andesites(probably closer to vogesite = syenitic lamprophyre).The highest SiO_2 content of ~ 60% and inverse correlation between Si & S (H.Wänke,personal communication)could indicate that more acid rocks also exist(Fe,S contamination is always present).We see them in the white & pinkish pebbles & crusts(without Fe signature) & in white floor under dark reddish soil.Fig.:increasing highland-lowland density dichotomy.



METAL-SILICATE INTERACTIONS IN METEORITES

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Ii is well known that the different chondritic groups exhibit a large variation in redox states, from oxidized CI chondrites to highly reduced enstatite chondrites, reflecting various environments during accretion of the meteorite parent bodies. In order to better characterize temperature and redox state of these environments, we have computed the compositions of metals and silicates in equilibrium under different T and fO_2 conditions, by using a numerical code based on free-energy minimization. We took into account non-idea activity relations, presence of Ni and solubility of silicon in the metallic phase and calculated the different sources of uncertainties on the calculations. With this model, we computed the Fe-Ni-Si contents of metal in equilibrium with silicates in various bulk compositions in the system Mg-Fe-Ni-Si-O. We verified that the simultaneous use of 3 (Fe, Ni, Si) redox markers is a powerful tool for discussing the T and redox conditions of meteorite parent bodies. Precise $T - fO_2$ relations were derived for EH, H, L, and LL chondrites. Additionally, their mineralogical compositions provide constraints on their accretion temperatures and therefore on their oxygen fugacities. These results are discussed in the light of previous $T - fO_2$ models of the solar nebula. Finally, calculations performed at higher temperatures provide some indications on possible metal and silicate compositions in the differentiating Earth.

THERMAL RELEASE OF XENON IMPLANTED INTO ARTIFICIAL ANALOGUE OF METEORITIC NANODIAMONDS

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The diamond micrograins found in primitive meteorites carry abundant xenon with unusual isotopic composition. Ion implantation is one of the ways for noble gases to enter the solid grains. We have studied the release patterns and the isotopic structures of Xe implanted into synthetic analogue of meteoritic nanodiamonds at energies below 1 KeV and released during pyrolysis at temperature up to 1200C. The substantial fractionation (up to 1% per amu), with enrichment of heavier isotopes and approximately linear mass dependence, was observed for Xe released above 700C. The release of other volatiles from nanodiamonds during heating in vacuum was investigated in addition and some information concerning the Xe release mechanism was obtained. Some possible explanations of observed fractionation are discussed.
This work was supported by RFBR-DFG (Grant 96-05-00038).

PS9 Lunar exploration

Convener: Foing, B.H.
Co-Convener: Hoffmann, H.

OBSERVATIONS OF LUNAR SODIUM FROM THE LUNARSAT: A MODEL

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The forthcoming lunar missions (e.g. LunarSat or Euromoon) will provide a good opportunity to continuously monitor the sodium exosphere around the Moon. A sensitive sodium D-line optical detector will be able to determine not only the column density of the atmosphere, but also will allow to estimate the mean thermal speed of atoms ejected from the surface. In that way, it will be possible to address some of the problems that arised after performing a series of ground-based observations in the recent years: (i) what is the contribution of different ejection processes (photodesorption, solar wind sputtering, meteoroid impacts) to the total sodium flux, (ii) what are the sticking and accomodation coefficients for ambient sodium atoms, (iii) how much is the velocity distribution of ejected atoms influenced by the gas-surface interaction. In the presentation we show how these questions can be answered by employing LENA: a narrow-band photometer counting the sodium photons along the line-of-sight. A procedure inverting the obtained column densities to the 3D spatial density will be described.

LUNAR PROSPECTOR'S POLAR ORBIT MAPPING MISSION

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Lunar Prospector (LP) is the 1st peer reviewed, competitively selected mission in NASA's new "Faster, Better, Cheaper" Discovery Program. The spacecraft is drum shaped (1.3 m dia. x 1.2 m tall), has a 296 kg wet mass and carries the science instruments on three 2.5 m long booms. Launch on a 4 stage LMLV-2 rocket is set for late evening, Jan. 5, 1998, from Cape Canaveral. The translunar coast will take 105 hrs during which the boom will be deployed and science instrument calibration data will be collected. LP will be insertion into a 100 km altitude, 118 minute period, circular, polar mapping orbit by 3 nearly 1/2 hr burns spread over 2 days. The nominal mapping mission will last 1 year followed by a 6 month extended mission during which high resolution mapping will be done from 10 km x 100 km elliptical orbits. LP's science payload consists of the following: A Gamma-Ray Spectrometer to map the elemental (K, U, Th, Fe, Ti, Al, O, Si, Ca & Mg) composition of the surface; Two Neutron Spectrometers to search for polar ice deposits and map the H distribution in the regolith; An Alpha Particle Spectrometer to determine the frequency and locations of gas release events; A Magnetometer and Electron Reflectometer to map the lunar magnetic fields and determine if he Moon has an iron core. The Doppler tracking data will be used to map the lunar gravity field and determine if the Moon has a core.

Measurement Results of a Stepped-Frequency Ground Penetration Radar Test Campaign In View of Planetary Exploration

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After years of technology investigations within the framework of ESA projects, RST is now performing measurement campaigns in order to practically demonstrate the viability of stepped-frequency ground penetration Radar on planetary missions. This paper will show first results of these campaigns. It will show the capability of this new Radar technique to perform with difficult soil structures. A prediction of its performance in planetary environments will be given for orbiter or rover based configurations. These measurements are undertaken by a very broadband GPR. It ranges from 1 MHz up to several GHz. It is an RST internal development for use of parameter optimisations with respect to dedicated mission requirements. In future, base on this instrument model, such Radars for Moon missions can be produced at a minimum cost. And, at the same time, they can meet demanding scientific requirements.

Simulation and Performance Prediction of an Orbiter based Planetary Ground Penetration Radar

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Constantin Mavrocordates, ESTEC, The Netherlands

Within the framework of the project PIRA (Planetary Into-the-Ground Radar and Altimeter) on behalf of ESTEC, RST AG built up a simulation in order to predict the performance of a planetary stepped-frequency ground penetration Radar. The simulation gives answers to the questions on range resolution and horizontal resolution in along and across track at surface and at different penetration depths. It shows how far Doppler processing works with the stepped frequency approach and what can be gained by multipath interferometry. It also touches the subject of surface return suppression in order to improve subsurface return visibility. The paper will provide an overview on the performance of such Radars with respect to soil layer determination and underground feature detection. The influence of the Radar frequency selection on the performance will be shown and calibration methods will be introduced allowing to significantly increase the underground measurement accuracy.

DARKNESS AT THE LUNAR SOUTH POLE, AS SEEN BY CLEMENTINE

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Clementine has provided, for the first time, a digital data set which can be used to analyse how the lighting conditions at the lunar south pole vary over the course of a lunar day. Data are available for a little more than two lunar days, permitting a preliminary assessment of how the lighting varies over the seasonal change from winter solstice to the vernal equinox at the southpole. In this study each Clementine orbit that imaged the south pole has been converted into a single image. By combining consecutive images into a quicktime movie we can see how the lighting conditions change at the south pole during a lunar day. Of particular interest are regions of lighting extremes. Both areas which appear to be in constant darkness as well as regions which are lit for much more the usual 50%. It is extremely useful to know the lateral extents of these areas as dark areas may contain water ice whilst highly illuminated regions are of value as potential landing sites. The production of a control grid for the Clementine data by the USGS in Flagstaff means that we know the position on the lunar surface in an image to an accuracy of approximately 250 m/pix. Thus analysis of these data will allow us to produce a ôpercentage illuminationõ map of the south polar region to a very high accuracy.

ANALYSIS OF LUNAR BASINS USING CLEMENTINE DATA

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Clementine imaged the Moon globally in eleven different wavelengths We have used the full resolution Clementine data (250 m/pixel) to undertake a compositional study of the ejecta blankets of several large impact basins on both the lunar near and far sides. Combining the Clementine UVVIS data together with Earth-based spectra we have been able to map the compositionally distinct units associated with the basins. As well as multi-spectral images new techniques have enabled us to produce quantitative maps of both iron and titanium content of the ejecta units, a tool which is extremely useful in identification of surface composition. By using the basins as probes into the lunar crust we have been able to build up a three dimensional compositional view of the crust. A good example is given by Orientale, a 900 km diameter basin located on the western nearside. We have been able to show that the basin ejecta units are largely homogeneous with the Montes Rook Formation being slightly more mafic than both the Maunder and Hevelius Formations. We have also been able to identify many outcrops of pure anorthosite, associated with the scarps of the Inner Rook mountain ring. Collectively this evidence points towards a three layercrustal model for the Moon. A mixed zone (megaregolith) overlying a region of pure anorthosite (representing the primordial lunar crust) on top of a more mafic basaltic layer.

AGES AND TiO_2-CONTENT OF LUNAR BASALTS: A STRATIGRAPHIC APPROACH

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Presented are new ages and geochemical data for several lunar nearside impact basins filled with mare basalts. From lunar samples returned by Apollo, it is known that TiO_2-rich basalts are generally older than TiO_2-poor basalts at these sites. We investigated this relationship in detail using remote sensing data and found no correlation between the TiO_2-content of a basalt and its age in any of the basins. In all basins it seems that the TiO_2-concentrations of the basalts vary independently from their ages, and that Ti-rich and Ti-poor basalts can erupt at the same time in the basin. However, the mean TiO_2-content of the basalts exposed in different impact basins generally decreases from the older basins to the younger basins. It is also obvious that with decreasing age of the basin the variety of compositions and range of ages increases. The widest range in ages occurs in Imbrium and Serenitatis which also contain the youngest basalt units, indicating that the volcanism lasted longer in these two basins than in the other basins. Stratigraphic columns show that the highest titanium basalts in each basin erupted at about the same time, although the absolute TiO_2-content differed from basin to basin. The frequency distributions of dated surfaces indicate that Australe, Tranquillitatis, Humboldtianum and Humorum were filled primarily in the period from 3.4-3.8 b.y. The broad variety of ages and compositions in Serenitatis and Imbrium are thought to be results of mixing and differentiation processes in the magma reservoirs or the mantle over long times. For Australe and Humboldtianum, we found clear evidence that lunar crustal thickness is a major factor in controlling the existence and amount of volcanism on the surface.

PS9

IDENTIFICATION OF LUNAR PICK-UP IONS IN INTER-PLANETARY SPACE: WIND/STICS RESULTS

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Observations of lunar pick-up ions were made by the WIND spacecraft during lunar flyby's in interplanetary space. The ion composition spectrometer WIND-STICS has measured these ions in the energy range 20-200 keV/e and with a mass/charge between 16-40 amu/e. The identification of singly charged heavy ions is rather difficult even with instruments of the WIND generation. Monte-Carlo simulations of the detector response for all ions at all energies of interest are necessary part of the identification process. We report in detail on analyzing STICS data with respect to different lunar pick-up ion species.

HIGH RESOLUTION ORBITER CAMERA FOR THE EUROMOON ORBITAL PHASE

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Before landing on the lunar surface, the currently investigated EUROMOON 2000 mission will remain in a circular orbit for 1 to 2 months. During this period, a camera instrument shall obtain monoscopic and stereoscopic imagery appropriate for the detailed analysis of potential landing sites, the final landing site selection, and for the support of the descent phase itself and subsequent surface activities. The required imaging data should have a high spatial and vertical resolution < 5m at a regional scale and a spatial resolution in the range of the lander dimensions (i.e. about 0.5 m/pixel) at a local scale. In order to meet these goals we propose a camera system consisting of two camera heads and a common digital unit for camera control, data buffering and processing. A compact single-optics pushbroom device with nine CCD-sensors will acquire simultaneously images high resolution (4 m/pixel), triple stereo and with six colors. It is inherited from the High Resolution Stereo Camera experiment developed for the Mars 96 mission. The second camera channel is a framing camera with a large area array detector, TDI capability, and a mirror optics with a focal length above 2 m yielding images at a spatial resolution of 0.4m/pixel from 100 km altitude. By making use of modern light-weight material, the mass of the entire camera experiment is well below 9 kg.

THE MOBILE PENETROMETER FOR THE LUNAR SOIL STUDY

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The mobile penetrometer is the self-propelled device for movement in the soil. Peculiarity of its usage for the soil study is an opportunity of penetration into the soil on significant depth, study of properties of the soil, soil sampling on the given depth, return to the surface, multiplicity of the penetration cycles. The definition of physical and mechanical properties on adepth can be determined at the known energy of impacts and their frequency. In such way the durability of separate layers, strength of separate layers, a presence of various formations, emptiness and etc. can be revealed. The mobile penetrometer has in the basis the shock mechanism. From this point of view the mobile penetrometer is the activator of seismic fluctuations. The energy of a shock pulse is well known and impacts follow in a strict sequence. Geophones are established on the given distance from the mobile penetrometer, forming a reception network with a various base. The mobile penetrometer is on the soil and makes a series of impacts. Geophones react to the single signals and operate according to the principle of accumulation. The possible range of sounding can be hundred of meters. Soil thermal properties can be estimated on the basic of dynamic of the mobile penetrometer body temperature changing under setted value of heat emission. The essence of their measuring is registration of mobile penetrometer temperature as function of the time under constant value of heat emission inside of the penetrometer and its cooling. Lunar heat flow can be estimated when measuring of the penetrometer temperature for different depth.

SURFACE TRANSPORT AND STORAGE OF WATER ON THE MOON

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A major goal in future lunar missions is to identify possible sites of subsurface ground ice which might have been supplied by meteorid and cometary impacts. An updated version of the Monte Carlo code for ballistic transport is used to investigate the "capture" efficiency of such exogenous water and other volatiles at the polar region of the Moon. Photodissociation and solar wind sputtering of the surface material will lead to the formation of an extended exosphere. The spatial distribution of OH and other sputted products will be compared with previous observations.

STRATIGRAPHIC STUDIES OF THE BOUNDARY REGION BETWEEN MARE SERENITATIS AND MARE TRANQUILLITATIS

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In the Mare Serenitatis/Mare Tranquillitatis border area different geological basalts of two maria are closely deposited surrounded by the Montes Haemus and Taurus-Littrow highlands. The Plinius and Dawes impacts have probed these basalts and the nearby Apollo 17 landing site provides ground-truth. An ideal region on the Moon for investigating complex geological settings. Telescopic spectra in the VIS to NIR wavelength range have been sampled at specific locations. Comparison of these spectral data with measurements in the same wavelength range of returned Aollo samples yield chemical information of the geological deposits in the considered area. The Plinius impact has penetrated the basaltic layers and exhibits anorthositic highland material in its central peak. The floors and rims of Plinius and Dawes contain basalts which are chemically different from the uppermost lava deposits hit by the impacts. The Dawes impact has also penetrated basaltic layers but has not reached the underlying highland materials of the buried basin rim. However floor and rim materials show similarities with Mare Serinitatis basalts suggesting that a defined stratigraphic sequence is established on the lava flooded rim crest of the two basins. This is supported by age estimations based on crater counts of distinct basalt units in this area. Dawes has penetrated at least two and Plinius three lava units.

A SIMULATION OF SATELLITE-TO-SATELLITE TRACKING MISSION NEAR MOON AND MARS

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One of the future possibility to obtain improved knowledge of the celestial bodies gravity based on the analysis of the relative motion of two (or more) satellites. In the case of low-low configuration mode where a low orbiting satellite tracks another in a slightly different low orbit observed along-track range-rate is directly proportional to the gravity potential difference. In the case of high-low mode where the tracking spacecraft is in a high orbit the most promising way is the transformation by differentiating the measured line-of-sight (LOS) velocity data into LOS-acceleration data.
Using computer simulation we have investigated several aspects of satellite-to-satellite tracking method. The simulation points to the fact that the closeness of low satellite orbit to the polar one is of importance to attain the greatest possible accuracy of gravity harmonics. An accuracy of reference gravity field is equally important. Compared to Moon, Mars turn out to be more sencitive to systematic errors of a reference gravity field model.

ON THE USE OF SATELLITE GRADIOMETRY FOR DETERMING GRAVITY PARAMETERS

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It is now widely recognized that satellite gradiometry will give the opportunity to yield a large divident in accuracy of charting a sharp gravity picture of celestial bodies.
The report concerned with the results of computer simulated satellite gradiometry experiments near Moon and Mars. It is strongly suggest that the incorporate adjustment of two or more different types of observed second derivatives of potential function provides the highest possible accuracy of estimated gravity harmonics.
In order to realize full efficiency of the method an appropriate inclination and altitude of satellite orbit must to be applied. Given a sufficiently large values, the inclination is almost of little cosequence. Contrary, the search of altitude faces some difficalties since for each N (the index of degree) it is desirable to use the altitude of its own.

SELENODESY FROM DIFFERENTIAL VLBI, RELAY SATELLITE AND LASER ALTIMETER EXPERIMENTS

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One of the main objectives of the SELENE mission is selenodesy by using differential VLBI, a relay satellite and a laser altimeter. Conventional RARR or Doppler measurements require direct communications between a lunar orbiter and a ground station. Furthermore, they have no or low sensitivity to the displacement of the orbiter on the plane perpendicular to the line of site. VLBI is, on the contrary, highly sensitive to the displacement on that plane.

We decided to apply new techniques of VLBI, the relay satellite and the laser altimeter. The relay satellite provides 4-way RR data of the lunar far-side for the first time, and the laser altimeter measures altitude not only at nadir but in the direction 40 deg. aside from nadir. Differential VLBI in addition to RARR permits 3-dimensional positioning of the satellite. These new kinds of data with high accuracy(1m in position and 5m in altitude) provide much information on selenodesy.

LUNAR OPPOSITION SPIKE MEASURED BY CLEMENTINE

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Imaging of the Moon by Clementine UVVIS camera gave a unique opportunity to study optical properties of the lunar surface at extremely low phase angles, where opposition spike, that is nonlinear increasing of surface brightness, occurs. In contrast to other studies, to measure the phase dependence of brightness we compared images of the same scene taken at different illumination conditions. For several sites we derived the dependence for the phase angles as small as 0.1 deg. A special technique provided high accuracy of our estimations. Generally, the brighter surface, the stronger opposition spike. We found that in spite of this trend, the opposition spike is steeper for shorter wavelengths, though albedo is lower. We found also that there are noticeable small-scale spatial variations of the opposition spike that are not controlled by surface albedo. These variations are due to the regolith maturity and particle size. Our findings prove studies of the opposition spike to be useful for remote sensing of the lunar surface.

THE PROBLEM OF THE SEISMIC EXPLORATION OF THE MOON

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We show the fundamental differencies and their reasons via seismicity nature and its manifestations for seismic and aseismic planets. The methods of physical seismology may become a sufficiently universal instrument for planets investigation. A comparison between seismicity characters of the Earth and of the Moon in particular have revealed the following: (1) the minor tectonic activity of the Moon manifests itself as trigger type seismicity with temporal mode defined by the spectrum of the tide's periods and their nonlinear time transformation and by impacts of meteoroids; (2) evolution of the wave field of moonquakes is accompanied by a secondary trigger action on the geological structure and an outgoing of the tectonic potential elastic energy in the microshocks form are represented as anomalously high quality and a secondary wave field of macroshocks sources spatial arrangement is represented as a diffusional field of scattered original signal; (3) radiation of waves in the Moon lithosphere is accompanied by seismic selfgeneration and a wave train can obey Fermy-Pasta-Ulom's paradox law.

THE DEEPEST LUNAR SPA BASIN AND ITS INFILLING

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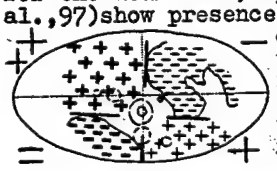
Universal tectonic dichotomy of celestial bodies(resalt of superposition of planetary waves lang $2\pi R$)is accompanied by tectonic sectoring caused by interference of the 1st obertone waves long πR. On the lunar far side there are 4 sectors centered in Orientale b.:2 differently subsided(SPA & Procellarum b-s)separated by two differently uplifted.The highest continental block-sector(++)is in a sharp & abrupt contact with the deepest SPA b.According to the angular momentum preservation law the highest block is composed of the lightest anorthosites(upto Na-enriched variety),the deepest block must be filled with rocks denser than Ti-basalts(typical for the near side).Spectral data(C.Pieters et al.,97)show presence of orthopyroxene. Some addition of lamellae NiFe and troilite will produce required dense rock.It might be like hovardites,mesosiderites,anomalous forsterite rich iron meteorites.& so on.



CRATER DEGRADATION ON THE LUNAR MARIA

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A correspondence is sought between the freshest class of craters on the lunar highlands and those on the less populated maria. A comparison by density suggests that the limiting age of this class is close to that of the plains themselves and, furthermore, that the process of crater degradation has been much faster on the maria than on the highlands. Both the Moon and Mars show not only an increase in the proportion of class 1 'sharply preserved' craters on their lowlands (maria/plains), but also of class 5 'fully ruined' craters in relation to the highlands. The increase in class 1 craters is expected as a result of the relative youth of the lowlands, but that of class 5 requires a more sophisticated explanation. One possibility is that crater degradation proceeded much faster on the later formed lowlands. This both reduces the density of the freshest, class 1 craters, and provides a mechanism for the generation of more degraded craters which might otherwise be expected to be absent from the newer surface. If this is the case, the age correspondence between highland and lowland craters is spread, the wide range of degradation on the maria relating to a narrower band on the highlands. A comparison by density suggests that the freshest craters on the highlands correspond in age to craters of all stages of degradation on the maria.

PS9

STRATIGRAPHIC RELATIONS AND SPECTRAL CHARACTERISTICS OF NORTHERN NEARSIDE LIGHT PLAINS

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Investigations of Lunar Light Plains on the northern nearside of the Moon are presented. In addition to the type location ("Cayley Plains"), i.e. the Apollo 16 landing site and the areas extending to the west, the areas north of Mare Frigoris exhibit a wide distribution of Light Plains. As in the equatorial latitudes, the role these smooth plains of intermediate albedo play in the geological evolution of the lunar surface is still poorly understood. Galileo multispectral data of the north polar regions allow to classify the Light Plains in at least two quite distinct categories: One with typical mare-basalt characteristics, the other exhibiting rather highland affinities. The lack of high resolution in these images (only ~1.2 km/pxl) could be overcome by Clementine multispectral images (res. ~1.2 km/pxl), which confirm and complement the spectral classification based on Galileo data. These results are combined with age determinations based on crater-frequency distribution-measurements on Lunar Orbiter imagery. Similar to the situation in the broad highland belt between Fra Mauro and the Apollo 16 landing site, where Light Plains are widespread, we found ages variing over a relatively long time scale. Consistent with results we got for the equatorial zone, this supports our assumption that an origin of the northern-latitude Light Plains cannot exclusively be attributed to the last two major basin-forming events, namely the Imbrium and Orientale impact. Because some Light Plains at the eastern margin of Mare Frigoris and in the vicinity of crater Meton have surfaces clearly younger than the Orientale event. Endogenic processes may have played a siginifcant role in forming the surfaces of some Light Plains in the investigated area.

THE JAPANESE LUNAR MISSION: LUNAR - A

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The Japanese lunar penetrator mission, LUNAR-A, will be launched in 1999. This mission aims to study the lunar interior using seismometers and heat flow probes in the penetrators. Two penetrators will be deployed on the lunar surface; one on the Oceanus Procellarum of the near-side, and another on the Mendelev Crater of the far-side. The data obtained by the instruments within the penetrators are first transmitted to the spacecraft orbiting at 200 km altitude and then sent back to the ground stations. The life time of the penetrator is estimated to be one year. The seismic study will be made by observing various deep moonquakes at two widely different sites. In particular, observations of the amplitudes and travel-times of near-side deep moonquake events at the farside will reveal core size of the moon, if it exists. Understanding the core size and its property are crucial to understand the bulk abundance of the siderophile elements, which in turn is essential to understand the origin of the moon.

MELISSA : preparation of flight experiments.

Lasseur Ch., Verstraete, W., Gros J.B., Gaudia F., Richalet J. Dubertret G., Diels L. Dixon M.

One of the real challenge of a mission further LEO (Moon or Mars) will be the establishment of an artificial ecosystem able to sustain human life. This final goal requires first a perfect understanding and control of the ecosystem behaviour. Although on Earth the control of an compartmentalised ecosystem seems to be possible, in space the effects of environmental parameters (radiation, reduced gravity, temperature, sun availability,...) have still to be quantified.
In the past 20 years, a large numbers of biological experiments (microbial, higher plant,..) have been performed to detect metabolic difference in zero or in one g gravity. Among these experiments, several ones were devoted to bacterial kinetic determination and their results seem to demonstrate higher kinetics in micro-gravity.
In this presentation, we quickly reviewed the general concept of the MELISSA project and we present the last scientific and technical results, the new facility devoted to a ground demonstration (a pilot plant in Barcelona). Then, we present the objectives, the concept and the current hardware development of 3 flight experiments (MASK, FEMME and BIORAT) related to MELISSA.

PHYSICAL LIBRATION OF THE MOON AND DISSIPATIVE PROCESSES IN LUNAR INTERIOR

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The importance information about interior structure and physical processes in the Moon may be obtained under study of the Lunar physical libration. Observation the planet rotation by the modern astronomical methods allow to reveal the fine effects in the precession and nutation (in other words - in libration). The case in point are the VLBI observations of radio beacons on the Moon with an accuracy of 0.1 mas, the certain detection of the Lunar free libration parameters by LLR analyses (0.01 arc sec), geophysical data about lunar interior after Appolo (dissipation factors Q) and Clementine (tomography of lunar internal structure). All these discoveries impose heavy demands on analytical description of the Lunar interior models.
For adequate description of observed lunar physical libration we consider the model of three-layer Moon: rigid crust, visco-elastic mantle and viscous core. Dissipative effects arising from the core-mantle interaction are of particular interest a) as the source of additional heating of the Moon's interior, b) as the mechanism supporting lunar free libration and c) as the region of mantle convective motion, plume tectonics and possible hot spots on the lunar crust.

LUNARSAT SCIENCE EXPERIMENTS

Rainer Riemann, Petrus Hyvonnen, Jan-Erik Wahlund, Peter Eckart

LunarSat is a micro satellite of 100 kg mass intended to fly to the Moon on as an Ariane 5 auxiliary payload. Several experiments have been proposed for LunarSat: a camera, a radar and plasma experiment, a gravity experiment, a sodium counter, a dust detector and an electron/ion spectrometer.
The camera system consists of a high resolution and a wide angle camera. The high resolution camera will take stereo and multicolour images of the lunar south pole region and other selected areas of scientific interest as lunar domes or rilles. This data will be used to obtain a digital elevation model and lithological information of these areas, especially of the Euromoon landing site. The wide angle camera will be used to monitor the changing illumination of the south polar region. It shall also be possible to obtain long exposure photographs of the eternally shadowed interior of the south polar crater by light reflected from the illuminated crater walls during lunar austral midsummer.
The radar and plasma experiment REX is a very versatile instrument: In passive mode it will study the lunar plasma environment. In the active mode it will also be used for surface and subsurface measurements.
The gravity experiment will be performed together with the Euromoon Lander spacecraft during its orbital phase. The sodium counter will be used to study the sodium content of the lunar exosphere.

SEARCH OF WATER ON THE MOON

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It is known that inverstigation of the lunar samples returned to the Earth by American and Soviet spacecraft did not allow to discover traces of water on the Moon. However the problem of existance of volatiles (in particular water) on the Moon in remote past or present is reserved for actuality. Three decades ago the possibility of existance of water (ice) in permanently shaded craters in polar regions of the Moon was pointed out by J.Arnold. The results of the Moon exploration by Clementine (1994) also testify in favour of that possibility. To resolve this problem the lunar polar lander was developed in framework of the proposed Russian Luna-Glob project. It is planed to drop this lander in the crater located in the region of South Pole of the Moon. The lander has a TV-camera, complex of scientific instruments, service equipment, radiotransmitter, RTG and other units. The lander is intended to explore a chemical composition and physical properties of the lunar materials at the landing site and internal structure of the Moon. The neutron detector and mass-spectrometr will be used on the lander for determing of water content in the lunar rock. The lunar polar lander desing, its scientific payload and program of operation on the Moon as well as expected results of the Moon exploration are considered in the report.

A COMPARISION OF CRATERING OF THE LUNAR POLAR REGIONS

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The comparision of the cratering of the lunar polar regions is fulfiled on the basis of the data bank of the Morphological Catalogue prepared by Sternberg Astronomical Institute and updated using the Clementine images and Arecibo radar mapping of lunar poles. There are more craters of diameter 10-40 km in the Southern region than in the Northen one but the number of craters of diameter more than 40 km is the same in the both regions. The histograms of crater frequency against degree of degradation shows that there are the same number of craters of the third class of degradation but there are more craters of the first, second and especially forth and fifth classes in the Southern region. The average of crater density in the 10 degree latitudinal bands decreases in direction from the North pole, but it increases from the South pole. Maps of crater density distribution were compiled for these regions. The values of the crater density were calculated for equal area segments and scaled to an area of 10 millions square km. Isolines were constructed through 50 craters. The maximum ctater density (850 craters) is observed in the region of Belkovich crater but the minimum (100 craters) in Mare Cognitum in the Northern polar region. In the Southern region more than 800 craters are observed in the neighbourhood of Bailly, Lemaitre, Mutus, but there are only 100 craters in the region of Shrodinger. So we may conclude that the basin Shrodinger is relatively young basin in the Southern polar region. The relative depths of the craters which are in the shadow in the south pole region were estimated on the base of our investigations of the main morphometrical parameters of lunar craters of different degree of degradation.

LUNAR IMAGER / SPECTROMETER OF SELENE MISSION

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SELENE(SELenological and ENgineering Explorer), which is the joint project of Institute of Space and Astronautical Science (ISAS) and National Space Development Agency of Japan (NASDA), is going to be launched by H-IIA rocket in 2003. In this mission, to accumulate knowledge for lunar science and to investigate the feasibility of the moon utilization in future are aimed. We, Lunar Imager/Spectrometer (LISM) working group, have studied feasibilities and begun to design three optical instruments for spectroscopic and topographic observation for this mission: Spectral Profiler (SP), Multi-band Imager (MI) and Terrain Camera (TC). The main purposes of their observations are to study 1) crustal composition and structure, 2) mantle material, 3) mare basalt volcanism and 4) tectonic activity of the moon. SP obtains continuous spectra with high S/N ratio and accuracy to identify mineral compositions. MI has such a high spatial resolution and wide spatial coverage that can discriminate geologic units in detail. TC obtains the global stereo image data with high spatial resolution of 10 m / pixel.

PERIODIC COMET SHOWERS AS PROBABLE SOURCE OF THE LUNAR VOLATILES

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Albedo anomalies - swirls on the lunar surface may be considered to be imprints of relatively recent cometary impacts. Characteristics and positions on the lunar surface of the swirl regions correspond to model of frequent giant "new" comet impacts about 10 myr ago. About ten comets came into contact with the Moon during time less than 10 myr. A such frequency of comet impacts may be qualifed as comet shower of high intensity. It is possible to calculate sizes and contact velocities of the comet bodies from analysis of the swirl fragments. The total mass of the shock-induced gases was about 2 milliards of megatons. It is equal to about 60 megatons of the comet water per square kilometer if distributed uniformly across the lunar surface. Certainly, the ice deposits would be remained into cold traps (permanent shadowed areas) only. Analysis of lunar relief near south pole showed that total area of the cold traps in this region is about 6300 sq. km. Therefore, the total amount of ice deposits in the south pole region which could be formed during last comet shower must be about 400 thousands of megatons. The total erosion loss of ice during last 10 myr is about 600 thousands of tons.

DIGITAL TERRAIN MODEL AT THE LUNAR SOUTH POLE FROM CLEMENTINE DATA

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Permanently shadowed areas (maybe even containing water ice) probably exist at the lunar south pole, as well as areas that are permanently sunlit. This is one of the most interesting landscapes for lunar exploration, even becoming a potential target for ESA's proposed Euromoon lander mission. In order to map the extent of areas in sunlight or shadow we carried out a topographic study of the south polar area. We identified 4,000 filter B images taken by the Clementine UVVIS camera with their image footprints within latitudes of < -75° S. We found 38 nadir pointed frames covering the area between 120°-220° W/ 89°-90° S suitable for stereo data processing that show the investigated area under different viewing angles. The stereo angles between image pairs are less then 3.6°. As a consequence the hight accuracy of approximately 2 km is relatively poor. Conjugate points and their respective coordinates have been identified, and absolute elevations have been determined by bundle block adjustment techniques. We derived a small digital terrain model (DTM) of about 60 km by 20 km with a grid spacing of 200 m, covering parts of the Eternal Peak of Light and the rim of crater Shakleton. The results indicate that the highest elevations near the south pole at 180° W/89.76° S are ~3 km above the mean lunar radius. This number is well above the data of current models. As a consequence the overall area in shadow could be smaller than previously calculated. Yet the results do not rule out permanently shadowed areas within deep craters in the vicinity of the south pole. The topographic information derived from this study possibly is of great value for future spacecraft exploration of the Moon.

EXPLOSIVE VOLCANIC ERUPTIONS ON THE MOON

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Although the Moon is deficient in volatiles compared to the Earth, its unique environment has allowed even minor amounts of volcanic gases to produce a diverse variety of pyroclastic deposits. Vulcanian eruptions produced deposits of low albedo glasses, like those seen in Alphonsus and Franklin craters. These localized Dark Mantle Deposits (DMDs) are several kms in size and surround circular pits aligned on linear rilles on the crater floors. Other localized DMDs are associated with small volcanic cones also aligned along linear rilles, but these eruptions are thought to be strombolian-style during degassing of near-surface dikes (i.e. Rima Parra V). Volcanic cones, like Isis and Osiris, formed by degassing and minor eruptions from the upper part of a near-surface dike where the large clasts cooled rapidly enough to produce spatter. We have recently identified a 160 km wide annular deposit of dark mantle in southern Orientale basin. The eruption can be modelled as degassing of a near-surface dike producing an umbrella-shape plume and emplacing volcanic glasses in an annular deposit. Other regional DMDs that extend for 100's of kms are composed of volcanic glasses and crystallized beads, with the amount of crystallization in the beads reflecting different optical densities in the volcanic plumes. These plumes probably resembled Hawaiian fire fountains except that much smaller clasts (<1 mm) were produced and expelled for 100's km by the expanding gas cloud. Because the deposits are large, unconsolidated, and produce more oxygen than other lunar soils when reacted with hydrogen, regional DMDs would make excellent sites for future lunar bases.

PS10 Interrelations between asteroids, near-Earth asteroids and meteorites

Convener: Froeschlé, C.
Co-Convener: Morbidelli, A.

DEBIASING THE DETECTED POPULATION OF NEOS

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The known population of NEOs is biased by observational selection (which favors the discovery of objects approaching Earth) and by the brightness of the objects themselves. In order to compensate for these factors, Jedicke and Metcalfe (1997, Icarus, in press) have developed a model-independent, analytical method for calculating the probability that an asteroid observation program will find a given asteroid in an $(a, e, i, H$; semimajor axis, eccentricity, inclination, and absolute magnitude) bin per square degree at opposition at the vernal equinox. Using this four-dimensional probability distribution, we can generate the orbital distribution of a "debiased" NEO population as a function of H. We will compare this prediction to direct numerical integration results of test bodies started both in (a) the ν_6, 3:1, and 5:2 resonances and (b) the orbital positions of 327 known NEOs. The former reflects a probable route through which main-belt ejecta "resupplies" the NEO population. The latter, while biased, represents a known set of NEO-starting conditions. Note that planetary encounters and secular/mean-motion resonances stir the orbital positions of most Apollo and Aten asteroids on short timescales ($<<$ 1 Myr), while most Amor asteroids are stable for much longer timescales ($>$ 1 Myr). Preliminary results show some success at reproducing the observed distribution of NEOs.

NEAR-EARTH ASTEROIDS ASSOCIATED WITH METEOR SHOWERS

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According to available data among the Near-Earth Asteroids (NEA) may be both former main belt asteroids and extinct comets. From the physical and dynamical observations of NEAs there are no considerable differences between asteroids having different origin. The important criterion, which can help us to determine the nature of concrete asteroid and identify it as a "dead" cometary nucleus, is the existence of NEA's observed meteor showers. In order to establish the association of NEAs with meteor showers we calculated the secular variations of the orbital elements of 22 numbered NEAs, 10 of which belong to the Taurid complex, by the Halphen-Goryachev method with allowance for perturbations from six planet (Mercury-Saturn). Results of calculations show that all these asteroids are quadruple-crossers of the Earth's orbit. Therefore, their possible meteoroid streams may produce in fours meteor showers. Theoretical orbits and radiant points of these showers are presented and discussed in terms of meteor observations. The NEAs are picked out which probably are extinct cometary nuclei.

ASTEROID SPECTRA AND METEORITE TYPES

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The asteroid belt shows a compositional structure: the surface composition of the objects varies radially with heliocentric distance. Asteroid composition reflects a trend from lighter to darker materials, which corresponds to silicatic objects in the inner part of the belt, to bodies of carbonaceous type in the middle region, to more primitive asteroids in the outer part.
Most of the progress in determining the bulk composition of the asteroids has resulted from spectroscopic studies of several hundred objects in the visual to near-IR spectral range, so that it has been possible to classify them in several taxonomic types. Recent CCD spectroscopy surveys allow us to have a better understanding of the compositional distribution of the population, and of the nature of asteroid families. Moreover, it is possible to have some hints on the origin of the group of Near-Earth Asteroids.
The research for asteroidal parent bodies of the various meteorite classes has made a significant progress in the last few years, even though the meteorites may represent an incomplete sample of the diverse range of materials present in the asteroid belt.
An overview of the last spectroscopic results obtained on asteroids and on asteroid families, in particular Eos and Flora, will be presented. Their relation with meteorite samples will be discussed.

DYNAMICAL INTERRELATIONS BETWEENS METEORITES, NEAS, COMETS, AND ASTEROIDS

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This review discusses the dynamical relationships between meteorites, near-Earth asteroids, main-belt asteroids, and comets. The evolving understanding of the dynamics of small bodies in the inner solar system, and more detailed observations of the physical and orbital characteristics of these bodies allows us to try to establish links between these populations. The available data from meteorites and near-Earth asteroids seems to tie them to the main belt, although some contribution from comets is still possible. The issue of 'parent bodies' for various meteorite classes, or for various spectral types of NEAs, looms large in the field. An attempt will be made to classify our knowledge of these relationships into (1) facts, (2) solid theories, (3) debatable theories, and (4) speculation.

MIGRATION OF BODIES TO THE EARTH FROM THE ASTEROID AND EDGEWORTH-KUIPER BELTS

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More than 1/6 of debris entering the 5:2 gap at eccentricity e=0.15 can reach the Earth's orbit in 0.1 Myr. Bodies migrate to the gaps mainly due to mutual collisions of asteroids. During the age $T_{\odot}$ of the Solar System, the resulting variation in semimajor axis a caused by mutual gravitational influence of bodies in the Edgeworth-Kuiper belt usually is less than 0.1 AU for a body in the middle of the belt and may exceed 1 AU for a body located in the inner edge of the belt. During $T_{\odot}$ for one among about ten beyond-Neptune (b-N) bodies, there can be jumps in a up to several AU as a result of separate close encounters. Under the gravitational influence of planets, separate b-N bodies can decrease their perihelion distances from 34 to 1 AU in several tens of million years. Most of Amor objects should have come from the asteroid belt. Perihelia or aphelia of bodies that collided with the Earth were located mainly near the Earth's orbit. A half of all Earth-crossing objects (ECOs) that colliding with Earth collide with it within $t \leq 5$ Myr after these objects became ECOs. The average time between impacts of 1 km bodies with the Earth may not exceed 0.1 Myr. Though the distribution of observed small NEOs in orbital elements differs from that of larger NEOs, these distributions may be almost the same of all small and large actual NEOs. This work was supported by the Russian Foundation for Basic Research and the Russian Federal Program "Astronomy".

TERRESTRIAL IMPACT STRUCTURES; AN INCOMPLETE RECORD OF THE IMPACT FLUX THROUGHOUT GEOLOGIC TIME.

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Approximately 160 terrestrial impact structures are currently known, with a discovery rate of 3-5 new structures per year. They range in age from ~ 2 billion to a few 10's of thousands of years and in size up to ~ 300 km in diameter. They represent a biased sample with respect to an originally much larger population of impact structures formed on the Earth throughout geologic time. Due to the effects of terrestrial processes, such as erosion and tectonism, the known sample is biased towards younger, larger impact structures on relatively well characterized cratronic areas of the Earth's crust. These inherent biases must be taken into account when using the known record to make generalizations about the impact flux and its character throughout geologic time. For example, the known record is sufficient to define an average cratering rate of 5.6±2.8 km $^{-2}$ a $^{-1}$ for craters with diameters greater than 20 km over the past 100 Ma. It is insufficient, however, to unequivocally determine if this flux has been constant over the last ~ 3 billion years, based on comparison with the lunar cratering record. Similarly, uncertainties in the accuracy and precision of the ages of terrestrial impact events, combined with small numbers statistics, preclude any definitive statements regarding periodicity in the terrestrial impact flux, as has been suggested based on arguments for periodic commentary showers.

MODELLING OF COSMIC BODIES FRAGMENTATION

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Fragmentation of cosmic bodies such as meteoroids, cometary fragments and asteroids in the atmosphere is studied. The velocity and ablation of the body in upper layers of the atmosphere are defined using the solution of equations of the physical theory of meteors. The aerodynamical and inertial forces acting on the body during its flight are considered. It is supposed that stress-deformation state of the body is quasystatic and it is defined by numerical solution of thermo-elastic equations. Numerical methods are used for the calculations. Various fragmentation criteria are used and corresponding values of accelerations at fragmentation heights are determined. Basic calculations are made for modelling of flight and fracture of icy body (Tunguska body) and metallic (Sikhote-Alin) meteorite. The simple model of impact of the body on the Earth surface, covered by water layer, is also developed. The cosmic body is simulated by sand, icy, metallic plates, cylinders and spheres. The parameters of all media are obtained for initial stage of the impact process. The numerical solution is made by finite-difference method.

The O.C.A.- DLR Asteroid Survey (O.D.A.S.)

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O.D.A.S. is a dedicated programme to search for asteroids and comets, with special emphasis on NEO's within the framework of the EUNEASO project, in cooperation and support of global efforts in NEO-research, initiated by the WGNEO of the IAU, and the Spaceguard Foundation. It is operated at the 90cm Schmidt-telescope of the OCA at Calern, north of Nice, France and the DLR - Institute of Planetary Exploration, Berlin-Adlershof, Germany. The current system uses a 2k CCD camera in combination with an automated asteroid detection software package. Operated since October 1996, the survey has discovered several NEOs and Marscrosser, and a large number of main-belt asteroids. The used hardware and software package will be briefly described, as well as the search strategy, analysis technique and operations. A summary of results and a future outlook of the project will be presented. A continous update of recent discoveries and the observing statistics can be found on the O.D.A.S. Webpage under URL http://earn.dlr.de/odas/odas.htm

AN EVIDENCE OF THE EXISTENCE OF CIRCUMSOLAR RING OF DUST PARTICLES NEAR THE EARTS'S ORBIT FROM GROUND BASED OPTICAL OBSERVATIONS

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The existence of the circumsolar asteroidal dust ring near the Earth's orbit have been derived from IRAS and COBE measurements (Dermott et al.,1993). According to this model Earth nears a denser part of the ring once a year, in the autumn monthes. This should have an effect on the annual variation of atmospheric influx of the sporadic meteor dust. We have analysed our long term phonometric data obtained in Abastumani astrophysical observatory by means of the twilight sounding method. The resulting annual curves of air turbidity at different altitudes of the meteoric zone of the upper atmosphere show clear autumn maximum with the turbidities 2 to 3 times higher than that of the other seasons. The typical height distributions of the air turbidities of different seasons are also obtained. The dust particles responsible for light scattering within 0.3 to 1 mkm spectral region where our observations had been carried out should be mainly of < 1 mkm diameter. Dermott, S.F., Durda D.D., Gustafson A.S., Jayaraman S., Liou J.C. & Xu Y.L.:1993.Asteroids, Comets, Meteors. Milani A. et al.(eds).

METEOR DUST PARTICLES IN THE EARTH'S UPPER ATMOSPHERE AND CIRCUMTERRESTRIAL SPACE BY TWILIGHT OBSERVATIONS

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The twilight sky photometry in visual region of scattered sunlight spectrum gives possibility to obtain rather regularly, and thus to follow its time behaviour, the vertical distribution of air turbidity in 20 to 300 km height interval for which faint low density dust particles of <1mkm diameter are believed to be mainly responsible. Those particles are scarcely detectable by radars. We have found from our twilight data obtained during 1960-1990 period that strong rise of air turbidity at altitudes above 60 km takes place during the periods of action of Quadrantids, Lyrids, Eta Aquarids, Perseids, Orionids, Geminids meteor showers. In the period of action Eta Aquarids of 1987, in particular, a dust layer with peak turbidity as high as ~20 formed at 110 km height and another, less intense one, at 70 km. A sequence of 17 observations gave an opportunity to determine the descending velocities of the layers and, from these, to evaluate the sizes of dust particles as 0.1 to1mkm. The influx into the atmosphere of background dust particles related with sporadic meteors as well as the existence of higher light scattering regions at 170, 200, 250 and 280 km are also revealed.

CHAOTIC DIFFUSION AND THE ORIGIN OF NEA's

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The short dynamic half-life (~ 10 Myr) of the near-Earth asteroids (NEAs) implies a large flux of the objects coming from the main belt. The chaotic diffusion in the main mean-motion resonances with Jupiter and in the secular resonance ν_6 furnishes one of the possible explanations of this flux, but, as it has been shown by Gladmann *et al.* (1997, Science **277**), the fragments injected into these resonances by the asteroidal collisions do not provide a sufficiently powerful source. In order to explain the presumptionally steady-state NEAs population, the above mechanism needs much more collisions in the asteroidal belt than it is inferred from the observational data.
An alternative solution of this problem may be based on the coupled effect of the higher-order mean-motion resonances and of the mixed resonances with the resonant angle:

$$\sigma = (p+q+r)\lambda_J - p\lambda - q\varpi - r\lambda_S \ ,$$

where λ, λ_J, λ_S are the mean longitudes of asteroid, Jupiter and Saturn, ϖ is the asteroid perihelion longitude, and p, q, r are integers. These later resonances have an advantage that they are quite dense and although being relatively small in size ($\lesssim 5 \times 10^{-3}$ AU), they fill a significant portion of the phase space.
In the presented work, we first constructed a simple analytic model of the mixed resonances, which allowed us to compute their position, approximate size and the time scale of the σ-oscillations, and then we checked the results by the numerical simulations (combining runs of real and fictive asteroids, maximum Lyapunov indicator computation and the frequency analysis). It may be conjectured that these resonances constitute the alternative routes from the main belt to NEAs, to those pointed out in Gladmann *et al.*

PS10

DYNAMICAL EVOLUTION OF NEAR–EARTH ASTEROIDS

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Numerical integrations of orbits of Near–Earth Asteroids (NEAs) on several millions of years as well as the development of semi–analytical methods have allowed to increase our knowledge on the dynamics of this population. Most of NEAs come from the main belt of asteroids through mean motion resonances with Jupiter or secular resonances but many uncertainties remain concerning their exact origins and parent bodies. In the terrestrial planet region (semimajor axes $a < 2$ AU), it has been found that their orbits are not only changed by close encounters with planets, but that they can also be affected by resonances. Mean motion resonances with inner planets and the Kozai resonance provide protection mechanisms from close approaches. Secular resonances are all present and those with the inner planets provide efficient mechanisms of transport to different orbital eccentrities/inclinations. Their effect is greatly increased in the zones where two of them overlap. Some peculiar mechanisms can also occur such as the interaction of the Kozai and secular resonances inside horseshoe orbits with inner planets. Finally different dynamical classes in the Mars–crossing population have been established and have confirmed the determinant role of resonances in the transport of these objects to the Earth or to high inclinations. Taking into account all these mechanisms, dedicated studies to the dynamical lifetime, orbital distribution and collisional probability of NEAs with planets can now lead to better estimates and are in progress.

3352 McAuliffe: Orbit and physical model of the DS-1 target asteroid

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The Deep Space One (DS-1) mission is scheduled for a historic first encounter with a Near-Earth Object, 3352 McAuliffe, on January 20, 1999. Images obtained during the flyby will allow us to determine global shape, rotational parameters, regional topography, and spectral properties of the target. The object, approx. 1.5 km in diameter, tentatively defined to be an S-type asteroid, currently approaches the Sun (a=1.87 AU, e=0.365, i=4.78°) and will become visible to potential observers beginning next summer. As little data are hitherto available, we suggest that international observational campaigns should be initiated to derive or refine the pre-encounter physical model of the object and herewith to support mission planning for DS-1 and science analysis of post-encounter image data.

PLANETARY COLLISION PROBABILITY FOR SINGLE-APPARITION ASTEROIDS

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We have defined the collision probability for planet–crossing asteroids using the Bayesian orbital a posteriori probability density at a given epoch (Muinonen and Bowell 1993, *Icarus* **104**, 255). On a given time interval, it is the six–dimensional phase–space integral of the probability density over those orbital elements that allow the asteroid to collide with the planet. For multi-apparition near-Earth asteroids, the linear approximation and a Monte Carlo method can be used for computing the collision probability, and there are methods to derive approximate bounds (Muinonen 1996, *Mem. Soc. Astron. It.* **67**, 999)—typically, the collision probabilities are found to be smaller than 10^{-10^X} with $X > 1$. For single-apparition asteroids, the collision probability computation becomes challenging because of the extreme indeterminacy of the orbits: for example, a single set of astrometric observations can allow simultaneous Aten-type, Hilda-type, and cometary orbital solutions. Nevertheless, based on the a posteriori probability density, we outline approximate bounds for the planetary collision probability of single-apparition asteroids.

ON THE ORBITS OF β–METEORIDS, $\beta > 1$

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The solar radiation pressure on sub-micrometer sized dust particles can exceed or even be larger than the gravitational attraction of the Sun. Both forces are proportional to the square of the distance, but with opposite signs. Hence, if the radiation pressure becomes the dominant force acting on the dust grain, the equation of motion will change sign, and the orbits of the dust grain are no longer Keplerian. The type of these orbits as well as the distribution of such β– meteoroids ($\beta > 1$) will be studied and first results will be presented.

COMPARATIVE STUDY "$P-D$" RELATION FOR THE MAIN BELT AND NEAR-EARTH ASTEROIDS

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Up to now many significant correlations between the various physical and dynamical parameters were found for the different asteroid populations. The aim of this paper is to study the relation between the rotation periods P and diameters D for the main belt asteroids with known P, D. For a search of connections for the correlation a useful technique of the computation of correlation coefficients $R(D,P)$ is applied. The coefficients $R(D,P)$ are calculated for all asteroids simultaneously in one sample and for the different groups. No significant correlation is evident for the whole asteroid sample. But it is found that the sub-groups of asteroids exist with the large value of $R(D,P)$. For the such sub-groups the linear rotational velocities on asteroid equator are near constant.
The comparative analysis of the derived results and my previous study of "$P-D$" relation for the near-Earth asteroids is presented. The correlation between various orbital parameters for the populations under investigation are discusses too.

SPECTROSCOPIC RELATIONSHIPS BETWEEN MAIN BELT ASTEROIDS AND NEAR EARTH ASTEROIDS

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In the very recent years dynamical studies on the evolution of NEAs allowed to understand the importance of the main–motion and secular resonances as the major routes to "jump" from the main belt to the inner planets region. In order to supply objects into the resonances it is necessary for the most that catastrophic breakups among asteroids occur quite close to the resonance border, leading to an important injection of fragments inside the caothic zone. In principle, any asteroid close enough to the resonance can be the Parent Body of fragments of different size, from meteorites to km–size objects. However, in order to give a real connection between the Parent Body and the present population of NEAs it is strongly necessary to find, when possible, a kind of compositional "flag", which might allow to extract among the main-belt objects the most probable birth–place of a given NEA asteroid or meteoritical sample. Spectroscopic studies of NEAs, asteroid families, as well as single objects "well" placed with respect to the resonances, have already evidenced strong connections between Vesta and the Eucrites and the V-type NEAs; interesting similarities have been also found between Hebe and the ordinary chondrites, the Eos family and some kind of carbonaceous meteorites, and possibly between the Maria family and some "giants" NEAs like Eros and/or Ganymed as well as with a certain kind of ordinary chondrites. Further and very promising studies are in progress.

YARKOVSKY THERMAL EFFECTS AS A SOURCE OF MOBILITY FOR ASTEROIDAL FRAGMENTS

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The idea of the thermal effects, consisting of a recoil force of the thermally reemited solar radiation, appeared about a century ago. However, a deeper understanding of their dynamical role in the solar system has been achieved only recently. Most importantly, two distinctive modes of the thermal effects – "diurnal" and "seasonal" – were recognized and carefully discussed. The diurnal version causes random changes of the semimajor axis with a characteristic time of the spin axis collisional reorientation. On the other hand, the seasonal version leads always to the orbital decay. The former is essential for the meter-size stone fragments and the larger-size objects covered with regolith. The latter turns out to be most efficient for about 10-meter sized stones and about 30-meter iron rich objects. The variety of the thermal effects thus promises to solve several important puzzles of meteorite science, especially the problem of the cosmic exposure rates.

PS11 Observation of solar-system objects with ISO

Convener: Encrenaz, T.
Co-Convener: Grün, E.

Sponsorship: ESA (European Space Agency)

OBSERVATION OF THE ZODIACAL LIGHT WITH ISO

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After reviewing our knowledge on the Zodiacal Dust, derived from earlier broadband photometry in the infrared (rocket/balloon-borne experiments, IRAS, COBE), we point out the fields where ISO could contribute to this knowledge significantly. We summarize the status of the ISOPHOT and ISOCAM observing programmes, and discuss the first results. The main emphasis is on the spectrophotometry of the Zodiaçal emission in the 6-16 um range, performed by both ISOCAM-CVF and ISOPHOT-S. The ISO spectrum is compared with the spectrum observed by the IRTS satellite, and by synthetic spectra of different mixtures of minerals. The most striking feature of the observed Zodiacal Light spectrum is its remarkable smoothness.

ISO OBSERVATIONS OF URANUS: THE STRATOSPHERIC DISTRIBUTION OF C_2H_2 AND THE EDDY DIFFUSION COEFFICIENT

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The infrared spectrum of Uranus has been recorded between 7 and 16.5 μm with the grating mode of the Short-Wavelength Spectrometer of ISO, with a resolving power of 1500. The 6-12 μm spectrum of Uranus has also been recorded at lower resolution (R=90) by the spectroscopic mode of the PHOT instrument. The spectra show no signatures other than the C_2H_2 band centered at 13.7 μm. The C_2H_2 band can be fitted with a mean stratospheric mixing ratio of 3 10^{-8}; this value refers to the 1-100 μbar pressure range. From the absence of emission in the region of the CH_4 7.7 μm band, and from the C_2H_2 fits using a photochemical model, an estimate of the eddy diffusion coefficient can be retrieved. Preliminary calculations indicate a very low value of this coefficient (between 10^3 and 10^4 cm^2s^{-1} at the homopause). This result is consistent with the values previously derived at the limb by the Voyager UV occultation experiments.

ISO OBSERVATIONS OF ASTEROIDS

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ISO observations of asteroids have been performed, with PHT-P, PHT-S and SWS, to better understand the surface composition of asteroids and to improve the knowledge of their origin and evolution.
Three different programs of ISO observations have been carried out on 16 asteroids. The first one, part of the central program "Observations of Galilean satellites and asteroids with ISO", includes the PHOT–40 observations of big asteroids. The second is "Dark, volatile–rich asteroids: possible relation to comets" which includes observations with PHOT–03 and PHOT–40 for dark and primitive asteroids. Four of them (10 Hygiea, 114 Kassandra, 308 Polyxo and 624 Hektor) have been also observed with SWS. The third program is "Rosetta target asteroids" which includes observations with PHOT–03 and PHOT–40 for 3840 Mimistrobell, the first target of the ESA Rosetta mission.
The 6–12 μm part of the spectrum has been fitted with a black–body curve for all the observed asteroids and the temperature has been computed for all objects. A thermal model has been applied to these thermal infrared observations to determine the diameter and the albedo. The obtained results and spectral analysis will be presented and discussed.

OBSERVATIONS OF HYDROCARBONS IN THE GIANT PLANETS WITH ISO–SWS

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The Short Wavelength Spectrometer (SWS) of the Infrared Space Observatory (ISO) recorded spectra of the four giant planets at a resolving power of ~1500. On Jupiter, Saturne, and Neptune, the 7–16.5 μm range exhibits prominent emission bands from CH_4 (and its deuterated isotope CH_3D), C_2H_6 and C_2H_2. On Uranus, only C_2H_2 emission is detected in this spectral range. Analyses of the spectra yield constraints on the abundance profiles of these hydrocarbons. In addition, on Saturn, methylacetylene (CH_3C_2H), diacetylene (C_4H_2), and possibly benzene (C_6H_6) have been detected for the first time. On Neptune, methyl radical (CH_3), a direct product of methane photolysis, has also been detected. I will review the existing observations and the information derived from preliminary analyses.

THE INFRARED SPECTRUM OF COMET HALE-BOPP OBSERVED BY ISO

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Spectra of comet C/1995 O1 (Hale-Bopp) were observed at medium resolution with PHT-S and at high resolution with the long- and short-wavelength spectrometers of the Infrared Space Observatory on September-October 1996, when the comet was at about 3 AU from the Sun. For the first time, a high-resolution spectrum of a comet covering the entire 2.4 to 200 μm spectral range was obtained. The vibrational bands of water, carbon dioxide and carbon monoxide are detected in emission with PHT-S, as expected from molecular fluorescence models. Relative production rates of 100:22:70 are derived for H_2O:CO_2:CO. H_2O is observed at high spectral resolution in the ν_3 group of bands around 2.7 μm, the ν_2 group around 6 μm with SWS, and in several rotational lines with LWS. The rovibrational lines of the ν_3 band are observed with a high S/N. This allows accurate determinations of the water rotational temperature and of its ortho-to-para ratio. Longward of 6 μm, the spectrum is dominated by dust thermal continuum emission, upon which broad emission features are superimposed whose wavelengths correspond to those of Mg-rich crystalline olivine (forsterite). The comet was to be observed again at the end of December 1997.

OBSERVATIONS OF NEPTUNE WITH ISO/LWS

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We report on the results from observations of Uranus and Neptune obtained with the ISO Long Wavelength Spectrometer (LWS) during the routine phase of the mission. Narrow band photometry was performed at ten wavelengths between 46 μm and 178 μm and spectra were obtained with a resolution of 0.29 μm from 43 μm to 90μm and of 0.6 μm from 90 μm to 197 μm. A high signal to noise ratio was achieved by combining the data of many identical calibration observations.
Both Uranus and Neptune have smoothly varying continuum spectra. The brightness temperature of Neptune lies between 58.3 K and 60.7 K in the observed wavelength range, using a model by Griffin and Orton as standard for Uranus. The surface brightness ratio of Neptune with respect to Uranus amounts between 60 μm and 160 μm constantly to 0.97 except near 100 μm where it exceeds 1.00.

ANALYSIS OF THE COMETARY DUST ENVIRONMENT BY MEANS OF ISOCAM IMAGING

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Comets are considered the link between diffuse interstellar medium and solar system since they contain a significant fraction of proto-solar unprocessed material. This is why they are primary targets for studies of astronomers and planetologists. The Infrared Space Observatory represents a unique opportunity to explore comets and their solid component in particular, at wavelengths not easily accessible from ground. In this work we present the results of broad-band imaging obtained by ISOCAM in the filters centered at 9.62 (LW7), 11.5 (LW10) and 15.00 microns (LW3). The target comets are: 65P/Gunn, 46P/Wirtanen, 2P/Encke and 103P/Hartley 2. Aim of the project is to analyse the coma and tail dust environment and to search for trails. Appropriate models are applied to the images to trace backwards in time the dynamic evolution of dust. This approach allows us to set constraints on relevant cometary parameters, such as velocity dependence on size and time, dust loss rate and size distribution, and, thus, to improve our capabilities of understanding and simulating comet evolution. This is a primary objective to be achieved in theview of future cometary exploration by space missions, such as ROSETTA.

THE 5-TO-7 MICRON SPECTRUM OF TITAN

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The spectrum of Titan was measured with the Short Wavelength Spectrograph in the 1430–1900 cm^{-1} (or 5.3–7.0 μm) region. Despite the very low level of flux – less than 3 Jy – adequate signal-to-noise was reached at least below 1580 cm^{-1} (or above 6.3 μm), a region that has already been explored by the Voyager IRIS experiment. Preliminary processing of the data shows good consistency with the IRIS results in that domain, in particular the presence of the prominent ν_3–ν_4 emission band of CH_4 centered at 1540 cm^{-1}, and a much broader emission feature at 1440–1480 cm^{-1} probably associated with several stratospheric emitters. This part of the spectrum corresponds to the very edge of the thermal regime in Titan's atmosphere. It is regulated both by photochemical haze particles and by molecular species present in the stratosphere. Modeling results will be compared to both the ISO/SWS and Voyager/IRIS data sets. Above 1600 cm^{-1} (or below 6.2 μm), one expects a sharp transition into the solar-reflected regime, with a significant contribution from the surface to the global reflectivity of Saturn's moon. Further data processing is in progress in order to bring out this scientifically important component.

TITAN THERMAL EMISSION FROM ISO OBSERVATIONS

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Observations of Titan in the thermal infrared were performed by ISO, using the Grating and the Fabry-Perot modes of SWS in the 2-45 μm region in January, July and December 1997, during Titan's Greatest Eastern Elongation. The resolving power of the SWS/Grating varies between 1500 and 3000 in the Grating mode and reaches 30000 in the Fabry-Perot mode, where some short observations were dedicated to the 15-16 μm region.
The 233-1500 cm^{-1} spectrum of ISO/SWS affords 10 times higher resolution than Voyager 1 /IRIS. We have modeled the spectrum using, as a first step, the Voyager-derived atmospheric parameters (Coustenis et al., 1993; Coustenis and Bézard, 1995) and have improved the precision of the thermal and compositional structure of Titan inferred on a disk-average.
A new temperature profile is available (from the analysis of the ν_4 CH_4 band at 7.7 μm), as well as more precise mean molecular profiles for the minor species with emission bands in the thermal infrared. We have inferred upper limits for some likely candidates in Titan's stratosphere (such as benzene and allene). Vertical profiles for HCN and C_2H_2 were tested against the observations.

SPECTROSCOPIC OBSERVATIONS OF SHORT-PERIOD COMETS WITH ISO

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Two Infrared Space Observatory programmes (guaranteed time and open time) were devoted to high-resolution spectroscopic observations of comets. They were aimed at short-period comets. 22P/Kopff was observed on October-December 1996 with SWS and LWS. Due to the weakness of the object at that moment, only the ν_3 rovibrational lines of water were detected, with SWS. They allowed a determination of the production rate of water in this comet and an analysis of its physical conditions. Comet 103P/Hartley 2 was to be observed at the end of December 1997. The ISO observations of these two short-period, Jupiter-family comets presumably originating from the Edgeworth-Kuiper belt, are to be compared to those of comet Hale-Bopp which came from the Oort cloud.

OBSERVATIONS OF THE GIANT PLANETS WITH ISO/LWS: DETERMINATION OF THE D/H RATIO

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The accurate determination of the D/H ratio in the giant planets has profound cosmogonical implications since its value at the time of formation of the Solar System, 4.5 billion years ago, is a critical cosmological parameter. For Jupiter and Saturn, the D/H ratio should be representative of the value in the primitive solar nebula since these planets have evolved little since they were formed; for Uranus and Neptune, on the other hand, the HD reservoir should be strongly enriched in deuterium because the hydrogen envelopes are thought to have been been mixed with volatiles originating from ices which made up the cores of these planets.
The Long Wavelength Spectrometer on ISO offers the unique opportunity to measure the first two rotational lines of HD in all four giant planets, from which the D/H ratios can be inferred. The results of these measurements will be presented.

JUPITER AND SATURN AT 2.5–5 MICROMETERS: COMPARISON OF ISO/SWS AND GALILEO/NIMS

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Observations of Jupiter and Saturn with ISO/SWS have provided spectra in the 2.5 to 16 μm range (de Graauw *et al.*, *Astron. Astrophys.* 1997; Encrenaz *et al.*, *Astron. Astrophys.* 1997), centered on the planetary disk (R≈1500, 14"×20" aperture). In the shorter wavelength range (2.5-5.2 μm), Jupiter spectra are compared to the Galileo/NIMS spectral images (Carlson *et al.*, *Science*, 1996) which are at R≈150 only, but at very high spatial resolution. Three spectral ranges provide a sounding of both atmospheres at different altitudes:
1) 2.5–3.2 μm range: the reflected sunlight is observed, with information on the upper clouds. On Jupiter, ISO observations give the first strong evidence for a spectral signature of NH_3 ice in Jupiter's atmosphere (Brooke *et al.*, submitted to *Icarus*).
2) 3.2–3.5 μm range: an emission from the ν_3 band of CH_4 is observed, both on Jupiter and Saturn. This emission is a signature of higher temperatures in their upper stratospheres than previously assumed.
3) 4.5–5.2 μm range: the thermal emission from the troposphere becomes dominant on both planets. ISO/SWS provides the first detection of H_2O vapor in Saturn's troposphere, with a large undersaturation factor, similar to the Galileo/NIMS findings on Jupiter (Roos-Serote *et al.*, submitted to *J. Geophys. Res.*)

A STUDY OF THE WATER VERTICAL DISTRIBUTION ON MARS FROM ISO AND IRAM MEASUREMENTS

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Spectra of Mars has been recorded in July-August, 1997 (Ls = 140-160 deg.) with the ISO Short Wavelength Spectrometer between 2.3 and 45 μm, with a spectral resolving power of 1500. A preliminary reduction of the 4-20 μm region has been presented by de Grauuw et al (ISOPeaks Workshop, Villafranca, October 1997), showing a good fit of the H_2O absorption lines with models including a constant H_2O mixing ratio of 2 10^{-4}. In addition, high-resolution Fabry-Perot scans have been recorded around several H_2O lines in the 25-45 μm range. The analysis of these lines shows that the water vapor vertical distribution is confined in the lower martian atmosphere, most likely by saturation. This results confirm the analysis of earlier observations of millimeter rotational transitions of HDO (226 GHz) and $H_2^{18}O$ (203 GHz), recorded in April 1997 (Ls = 100 deg.), at the 30-m IRAM antenna. The millimeter data clearly indicate a maximum H_2O abundance in the northern hemisphere, and a strong depletion of the vertical profile as the altitude increases. The depletion is likely to be due to water saturation.

ISO SPECTRA OF CALLISTO AND GANYMEDE FROM 2.38 - 196 MICRON

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Infrared spectra of the galilean satellites Callisto and Ganymede have been recorded between 2.38 and 196 μm covering the full wavelength range of the Short-Wavelength and Long-Wavelength Spectrometers of ISO. The spectra were taken in grating mode at resolutions between 1000-2000 and 150-300 in the ranges 2.38-45 μm and 45-196 μm respectively. We present the disk averaged spectra together with the observational details and a discussion of potential straylight from Jupiter. We will provide brightness temperatures for the thermal emission and a discussion of the albedo at the short wavelength sides of the spectra.

ISO SPECTROSCOPIC OBSERVATIONS OF ATMOSPHERIC COMPONENTS ON JUPITER AND SATURN SATELLITES

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Recent Galileo observations have shown the presence of tenuous oxygen atmospheres on Europa and Ganymede. In order to search for other atmospheric components and to find indications of atmospheres in other satellites, we have made spectroscopic observations using the Short Wavelength Spectrometer on board ISO of the Jupiter satellites Europa, Ganymede and Callisto. The corresponding observations of the Saturn satellite Iapetus are scheduled to be executed in the near future. In particular, we have searched for H_2O, OH, CO_2, C_2H_2 and O_3. We will present the abundances and mixing ratios (or upper limits) derived for these molecular species, compare with previous results when available and discuss implications for the gas chemistry on these satellites.

OBSERVATIONS OF THE GIANT PLANETS WITH ISO-SWS: EVIDENCE FOR EXTERNAL OXYGEN AND DETERMINATION OF THE D/H RATIO

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Infrared spectra of the Short-Wavelength Spectrometer of ISO have allowed the first detection of stratospheric H_2O on Saturn, Uranus and Neptune, and CO_2 on Saturn and Neptune (Feuchtgruber et al., 1997, Nature, 389; de Graauw et al., 1997, A&A, 321). Derived mixing ratios of a few ppb prove the existence of an external source of water, either from infalling meteorids or ring/satellite material. First observations indicated H_2O and CO_2 in similar amounts on Jupiter (Lellouch et al., ISOPEAKS Workshop, 1997, in press). We will present high quality spectra of H_2O and CO_2 lines on Jupiter, based on SWS Fabry-Perot observations at spectral resolutions of ≈30000, compare the required external H_2O fluxes with those on the other giants and summarise implications for their atmospheric chemistry. We will also determine the D/H ratio on Uranus based on the first detection of the HD R(2) line and report on the search for HD R(2) and R(3) lines at Saturn. Preliminary values of D/H on Jupiter and Neptune (Lellouch et al., 1996, Bull. Amer. Astron. Soc, 28; Lellouch et al., 1997, ISOPEAKS Workshop, 1997, in press) are refined by including observations of H_2 S(0) and S(1) lines to improve on the temperature profile.

ISOPHOT OBSERVATIONS OF THE PLUTO/CHARON SYSTEM

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The Pluto-Charon system has been observed by the Imaging Photopolarimeter of the Infrared Space Observatory (ISOPHOT) in four filters at 60, 100, 135 and 200 microns. In an attempt to determine the surface temperature distribution of Pluto, observations were repeated for 6 to 8 (depending on the filter) rotational phases of the Pluto-Charon system. The main results are the following: (i) the system is clearly detected at all four wavelengths (ii) the measured flux levels confirm that the surface brightness temperature is higher in the far-IR than in the millimeter/submillimeter, although the fluxes at 60 and 100 micron are slightly below those determined from IRAS (Sykes et al. Science, 237, 1336, 1987) (iii) the data suggest emissivity variations between the four filters (iv) the data indicate a rotational lightcurve at 60 micron and more marginally at 100 micron. With a maximum near L=100° (L is the east longitude of Pluto) and a minimum near L=200°, the thermal lightcurve appears to be anticorrelated with the visible lightcurve (see Buie et al. Icarus, 125, 233, 1987). Efforts to model the data in terms of three different surface units (Charon, Pluto "bright" regions, and Pluto "dark" regions) in accordance with HST imaging are underway and will be presented.

OBSERVATIONS OF JUPITER WITH ISO-SWS : TEMPERATURE AND COMPOSITION OF THE STRATOSPHERE AND UPPER TROPOSPHERE

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ISO-SWS offers a continuous spectral coverage of Jupiter from 2.4 to 45 μm at a resolving power of 1500. These observations show for the first time the core of the ν_3 band of CH_4 (3.31 μm) in emission, unveilling a warm upper stratosphere. Together with the ν_4 (7.66 μm) and ν_2 (6.52 μm) bands of CH_4, and the H_2-He continuum, this allows to inverse simultaneously the temperature profile at atmospheric levels ranging from the upper troposphere up to 10 μbar. From the 10-14.5 μm region we retrieve the vertical profile of photodissociation products of methane (C_2H_2, C_2H_6) in the stratosphere consistent with the temperature profile. Mixing ratios and vertical profiles of tropospheric species (NH_3, PH_3, CH_3D) are derived from the 6.5-7 μm and 8-10 μm regions. ^{13}C and ^{15}N are detected in the form of $^{13}CH_4$ and $^{15}NH_3$, and $^{13}C/^{12}C$ and $^{15}N/^{14}N$ are determined. The CH_3D mixing ratio leads to a determination of the D/H ratio.

OBSERVATIONS OF SIV IN THE IO PLASMA TORUS WITH ISO

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The physical processes maintaining the Io plasma torus (IPT) are still not fully understood. One fundamental gap in the knowledge of the IPT is the origin of highly ionized species such as OIII and SIV. The electron temperatures in the IPT are maybe too low to maintain these species if the IPT is in local thermal equilibrium. As a possible creation mechanism for these species an influx of energetic electrons from the outer magnetosphere has often been invoked. But while the presence of OIII is well established from measurements in various wavelength regions and seem to support these models, observations of SIV, which could set further constraints on the models are somewhat contradictory. For example, IUE measurements showed 4 times lower brightnesses than predicted from Voyager UVS observations. Since SIV has no optical emissions and the UV line is rather weak, up to now there was no way to resolve this contradiction. The launch of ISO made it possible for us to observe the SIV emission at 10.51 μm, which is considerably stronger than the UV emission.
The observations took place on 25 May 1997. SIV was detected with the Short Wavelength Spectrometer at both ansae at an intensity of approximately 0.5 Jy. Observations were obtained at 4 different magnetic longitudes. Furthermore, serendipitous observations of the SIII 33.48 μm emission were obtained simultaneously. We present the observations and preliminary analysis of the data.

MARTIAN MINERALOGY FROM MID-INFRARED SPECTRA: PROSPECTS WITH NEW SHORT WAVELENGTH SPECTROMETER OBSERVATIONS

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New high resolution spectra ($\lambda/\Delta\lambda$ = 1000-3300) of Mars were obtained at high S/N with the ISO-SWS on 15 and 31 July 1997, and 20 August 1997, with central meridians crossing the equator near the *Sinai Planum*, *Syrtis Major Planum*, and the *Tharis Montes*. Over a 2.38-45.2μm baseline, these spectra contain solid state features whose spectral position, shape, and persistence allow (1) some disk-averaged description of the silicate, carbonate, and sulfate minerology and its surface versus weathered airborne origins, (2) a test over the 8-12μm region of recent models of airborne dust based on a palagonite-like composition, and (3) an association of strong absorption rougly between 30-40μm to different ferric oxides or oxyhydroxides in surfacial or airborne dust by comparison to laboratory transmission spectra. We overview the prospects for these studies.

ASTEROIDS AS FAR-INFRARED STANDARDS FOR CALIBRATING ISOPHOT

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Asteroids are used as primary calibrators for the ISOPHOT on the Infrared Space Observatory, in the wavelength range 50–200 μm. In the far-infrared the asteroids covers a large dynamical range between the bright planets and the faint standard stars.
Ten asteroids were selected in the planning of the project, which have been investigated in extensive ground based and airborne observing programmes. They cover a wide range of fluxes, and the probability is high for at least one object to be visible at any given time. Using the thermal model by Lagerros (1996, A&A 310, 1011; 1997, A&A 325, 1226) we derive new thermophysical parameters of the selected asteroids, which makes it possible to predict the thermal emission of the asteroids with an absolute accuracy of 5–10 %.
The physical properties derived indicates large surface roughness and very low levels of heat conduction. Due to radiative transfer processes in the porous regolith, the emissivity varies significantly with wavelength.

FUNDAMENTAL THERMAL EMISSION PARAMETERS OF CERES – DERIVED FROM ISO OBSERVATIONS

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The asteroid Ceres is the largest and by far the best known object of the main belt. At around 20 μm, where the thermal emission of main belt asteroids typically peaks, Ceres is more than 1 order of magnitude brighter than the brightest stars. It is therefore an excellent scientific object for an extensive study with ISO at wavelengths between 2 and 200 μm.
We present observations from SWS, LWS and PHT at wavelengths between 2 and 200 μm. Two SWS spectra of Ceres, taken at different times, cover the range from 2.4 to 45.2 μm, including the maximum of the thermal emission. We derived the temperature distribution on the surface of Ceres and discuss the effects of surface structure, which influence the temperature distribution. LWS observed Ceres more than 10 times in fixed-grating position, providing each time 10 photometric data points between 46 and 178 μm. Additionally a full grating scan from 43 to 196 μm has been obtained. We demonstrate that, due to scattering processes within the surface regolith, the emissivity decreases towards longer wavelengths. ISOPHOT photometry was obtained between 50 and 200 μm. By combining the flux density variations at different phase angles before and after opposition, we could derive the thermal inertia of Ceres and confirm a very low value of $\Gamma < 10\, Jm^{-2}s^{-1/2}K^{-1}$.

OBSERVATIONS OF JUPITER AND SATURN WITH ISO/LWS: MEASUREMENT OF THE FABRY-PEROT SPECTRUM

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The ISO mission represents a unique opportunity to measure the far-infrared spectra of the planets. The spectra of Jupiter and Saturn have been measured using the Fabry-Perot interferometers (resolving power $\sim 10^4$) in the Long Wavelength Spectrometer (LWS). For Jupiter, one end-to-end scan was made (47–197 μm) in addition to several scans over narrow wavelength ranges dedicated to particular expected transitions. For Saturn, only the latter type of observation was made.
The full Jupiter scan reveals the following results: all of the predicted NH_3 manifolds have been detected; two absorption lines of PH_3 have been detected at 113 and 141 μm; H_2O has been detected weakly in emission at 66.4 and 99.5 μm; and two weak absorption lines of HF have tentatively been detected. The Saturn observations are under analysis and are expected to yield similarly promising results. The measurements and their analysis will be presented.

OBSERVATIONS OF JUPITER AND SATURN WITH ISO/LWS: MEASUREMENT OF THE GRATING SPECTRUM AND DETECTION OF METHANE

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The far-infrared spectra of Jupiter and Saturn measured with the ISO Long Wavelength Spectrometer (LWS) are presented. The data comprise grating mode scans covering the ranges 55-90 μm for Jupiter and 40-200 μm for Saturn and high spectral resolution Fabry-Perot scans of forbidden rotational methane lines at 106, 119 and 127 μm. There was good agreement between the Jupiter grating data and an atmospheric radiative transfer model using expected values for the constituent vertical concentration profiles of hydrogen, helium and ammonia. For Saturn, comparison of the observed and simulated spectra revealed differences in the phosphine absorption features which were reconciled by modifying the vertical abundance profile of PH_3. Modelling of the forbidden rotational methane features has provided important new estimates for the C/H ratio in the Giant Planets. Differences between near- and far-infrared estimates may be due to uncertainties in the theoretical forbidden line strengths and innacuracies in modelling the effects of scattering at shorter wavelengths.

THE DARK SIDE OF IAPETUS

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We have succeeded in recording the 2.5 - 3.5 micron region of the spectrum of the dark, leading side of Saturn's mysterious moon Iapetus. We confirm the existence of a very strong broad absorption feature at 3 microns identified in previous low resolution spectrophotometry. The new observations allow this feature to be studied in detail for the first time. Combining our observations with previous work, we now have the spectrum of the dark side of Iapetus from 0.3 to 3.5 microns. Fitting models to this spectrum, we have established that organic material is required to explain the dark surface. The nature and the origin of this material will be discussed.

DETECTION OF METHYL RADICAL IN NEPTUNE'S ATMOSPHERE FROM ISO–SWS OBSERVATIONS

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We report the first detection of methyl radical (CH_3) in the atmosphere of Neptune. Spectra were recorded on 12 November 1997 using the Short Wavelength Spectrometer (SWS) of the Infrared Space Observatory (ISO) in the grating mode. The spectral range 16.44–16.56 μm was observed during 50 min of integration at a resolving power $\lambda/\Delta\lambda \approx 1500$. The final spectrum shows prominent emission from the ν_2 band of CH_3 centered at 16.497 μm (with a S/N ratio of about 30). This emission feature can be reproduced with a CH_3 column density of about 2×10^{13} cm^{-2} in the upper atmosphere. We then used the observations to constrain a one-dimensional hydrocarbon photochemical model. Model output, (CH_3) mixing ratio vs. altitude, was used to generate synthetic spectra that were then compared to the observed spectrum. We will report on the model sensitivity to the assumed CH_4 mixing ratio in the lower stratosphere, eddy mixing profiles, H flux from the ionosphere, and uncertainties in the photochemical reaction scheme.

ISO-SWS SPECTRA OF THE MAJOR ASTEROID CLASSES : CLUES TO MINERALOGY AND CHEMISTRY OF THE SOLAR SYSTEM

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We present the first results of our ISO observation programme studying the morphology of asteroids of the major asteroid families. The programme consists of infrared spectra of Ceres (G type), Pallas (B), Europa (CF), Vesta (V), Juno (C), Amphitrite (S) and Herculina (S). The spectra are recorded at resolutions between 1000 and 2000 covering the full wavelength range of the SWS (2.36μm-45.3μm). Comparison of mid-infrared spectra of minor planets with laboratory data on meteorites, stratospheric Interplanetary Dust Particles (IDPs) and other ISO mineralogy studies on satellites, comets, zodiacal light, and circumstellar dust disks of stars at different stages in their evolution can provide insight in evolution scenarios for dust in stellar systems and the place of asteroids in the chemical evolution of our Solar System.

THE SPECTRUM OF IO FROM ISO-SWS OBSERVATIONS

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The near infrared spectrum of the leading side of Io has been recorded by the short wavelength spectrometer of ISO (SWS) from 4200 to 1900 cm^{-1} (2.4 - 5.3 μm) at high spectral resolution ($R \approx 1500$). We present the results of a first analysis consisting in the assignment of the bands mainly due to solid SO_2 and its isotopes, the determination of the surface temperature of SO_2 ice and the assessment of the existence of a vertical gradient. A first modeling of Io's reflectance spectrum already allows to draw some conclusions on the state of the surface. One is that the 3584 cm^{-1} (2.79 μm) band observed is only due to the $2\,\nu1 + \nu3$ combination band of solid SO_2 with no contribution from diluted H_2O molecules, contrary to what was proposed before (Salama et al. 1994). The question of the isotopic abundances are also investigated. Finally, the modeling tries to constrain the SO_2 frost coverage of the leading hemisphere and shows that grain size distribution seems to occur, as suggested before (see Schmitt et al. 1994).

GROUND OBSERVATION AND DETECTION OF MOLECULAR LINES OF C/1995 O1 HYAKUTAKE AND C/1997 O2 HALE-BOPP IN TELLURIC WATER VAPOR ABSORPTION BAND NEAR 9360 ┼

We report high resolution observations of comets C/1995 O1 Hyakutake and C/1997 O2 Hale-Bopp in the telluric water vapor absorption band near 0.93 microns. Observations were made during two scheduled shifts at Observatoire de Haute-Provence 1.52 m telescope, using a high resolution spectrometer (AurÚlie, R = 110.000) in the 24th order of a 79 mm-1 echelle grating. Detector is a Thomson barrette with a dispersion scale of 0.035 ┼ pixel-1 or 2.52 ┼ mm-1. A synthetic H2O spectrum calculated at observatory level (z=665 m) on an optical path of 10 meters, typical of the physical absorbing path inside the spectrograph, is used for spectral calibration. Another one calculated using the HITRAN code between z = 665 m and z = +â at observation zenith angle is used for substraction of water vapor absorption along line of sight.The spectral range of 9310-9450 ┼ along the ê 140 ┼-width interferential filter is covered during two separate exposures at two different grating angles. This range is seldom explored from ground because of the difficulty of dealing with terrestrial H2O absorption, and were specifically undertaken to complement from ground ISO ISOPHOT-S and SWS observations. Both comas, tracked near perigee by drift adjustment of telescope motion and manual tracking, show specific molecular lines that were corrected from cometary Doppler. We discuss the detection of H2O in these observations and compare the detection level to ISO measurements.

ISO OBSERVATIONS OF KUIPBER BELT OBJECTS

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The ISOPHOT experiment on ISO was used in an attempt to detect thermal emission from several of the brightest Kuiper Belt Objects. Detailed signal to noise calculations prior to launch suggested that these objects should be detectable with the instrument complement on ISO. However, the reduction has revealed that the identification of the objects is not so straightforward. We report on the latest analysis of the data and attempt to reach conclusions on the albedo and diameters of KBOs.

PS12 Planet formation and extra-solar planets

Convener: Barge, P.
Co-Convener: Morfill, G.E.

Sponsorship: Laboratoire d'Astronomie Spatiale, International Astronomical Union (IAU), Committee on Space Research (COSPAR), Centre National de la Recherche Scientifique (CNRS), Institut des Sciences de l'Univers (INSU), Centre National d'Etudes Spatiales (CNES)

THE DISCOVERY OF EXTRASOLAR PLANETS

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Within the last two years planets have been discovered around 8 nearby Sun-like stars. All of these planets have been revealed by the gravitional influence they have on their host star. For example, Jupiter gravitationally tugs the Sun in a small counter orbit with a velocity amplitude of 12 m/s. This motion is detected as a variable Doppler shift in the spectrum of the host star.
The planets detected to date have profoundly challenged the theories of planet formation, including Jupiter-mass planets in very small (4 day) orbits, and Jupiter-mass planets in extremely eccentric orbits. Only the 47 Ursae Majoris system, with a Jupiter-mass companion in a circular orbit with a period of several years, reminds us of the Solar System.
Now that planets have been detected, we would like to know what fraction of stars have planets, what fraction of planetary systems are similar to the Solar System, and how many other types of planetary systems exist. Toward this goal our group is carrying out surveys of all 500 of the nearest, brightest Sun-like stars using the Lick 3-m (California), Keck 10-m (Hawaii), and the 3.9-m Anglo-Australian Telescopes. Our currently precision, 3 m/s, is sufficient to detect Saturn-mass planets within 1 AU, and Jupiter-mass planets within 5 AU.

PLANETESIMAL DYNAMICS WITH A MASSIVE PERTURBER

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N-body simulations of the evolution of a swarm of planetesimals perturbed by a massive Jupiter-like planet were performed with the GRAPE-4 system recently installed in Marseille. The planetesimals are originally distributed in a ring located within the orbital radius of the perturber. A rotating tightly wound spiral density wave is found to form rapidly in the swarm. We will discuss the properties of this spiral and link them with those of the perturber and of the initial distribution of the planetesimals. Possible consequences on the extra-solar planetary systems will be explored.

TRAPPING OF DUST BY COHERENT VORTICES IN PROTO-PLANETARY DISKS

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It has been suggested recently that long lived vortices in circumstellar disks could capture particle dust and facilitate the formation of planetesimals. We have explored this scenario by considering the dynamics of a single vortex in a keplerian shear. We have investigated the influence of viscosity, differential rotation and compressibility on its lifetime and we have considered the interaction between the vortex and the surrounding dust particles to determine if the vortex can act as a trapping region and be relevant in the process of planetesimals formation.

ATMOSPHERIC AND OCEANIC CONTRIBUTIONS TO THE LONG PERIODIC COMPONENTS OF NUTATION

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Earlier studies of the atmospheric effects on precession/nutation (Dehant *et al.*, 1996; Hinderer *et al.*, 1996; Gegout *et al*, 1997; Bizouard *et al*, 1997) indicate that in addition to the main influences, which are the annual and semiannual terms, there can also be non negligible contribution to the constant pole offset, long periodic components of nutation, and precession. However, depending on the approach used – one is based on the atmospheric angular momentum, the other one on the atmospheric torque upon the Earth – the results given by these authors differ significantly. In this paper, we attempt to clarify this discrepancy by investigating the role of the gravitational tidal torque acting on the atmosphere. The oceanic contribution is also considered.

SPECTROSCOPIC OBSERVATION OF THE β PICTORIS DISK WITH ISO

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β Pictoris with its wide circumstellar disc of dust and gas represents today probably the missing link in the scenario of planetary formation between young circumstellar discs surrounding newly formed stars and a mature planetary system like our own. Spectroscopic observations reveal a complex gaseous environment with, besides a permanent disc of gas, common sporadic infall of gas and very rarely a few outflows. Variable signatures are partly interpreted in terms of evaporation of kilometer-sized bodies close to the star, but the origin of the stable gas is however still debated.
We used the Short Wavelength Spectrometer on ISO to observe β Pictoris in high resolution. Our goal is to look for gaseous signatures of volatile key elements as well as possible molecular ones. These detections could bring new informations on the nature of the stable gas and on the evaporation processes which likely occur within the disc. The data reduction is currently under way and we will present preliminary results.

MODEL BOND ALBEDOS OF EXTRA-SOLAR GIANT PLANETS

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We have modeled the atmospheres of extra-solar giant planets with varying effective temperatures and gravities, with and without clouds (see abstract by Stephens *et al.*). We compute Bond albedos by calculating the ratio of the flux reflected by a planet (integrated over wavelength) to the total stellar flux incident on the planet. This quantity is useful for determining the temperature structure and evolution of a planet. We find it is sensitive to the stellar type of the primary. For a 7 M_{Jup} planet the Bond albedo varies from 0.4 to 0.3 to 0.05 as the primary star varies from A5V to G2V to M2V in spectral type. We also find that the Bond albedo increases as the gravity increases for a planet with a given effective temperature. The Bond albedo is relatively insensitive to changes in the effective temperature of the planet for a cloud free model. Water clouds act to increase the reflectivity of the planet in the red, which increases the Bond albedo. The Bond albedo increases by an order of magnitude for a 13 M_{Jup} planet with an M6V primary when water clouds are added. Silicate clouds, on the other hand, lower the reflectivity (by a factor of 2 in some cases) of the planet, which lowers the Bond albedo.

We present results showing the integrated Bond albedo for a selection of extra-solar giant planets and stellar types.

GIANT PLANET FORMATION: LEARNING FROM THE INSIDE

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The knowledge of the interior structure and composition of the giant planets is crucial to the understanding of their formation. I will present the latest interior models of Jupiter, Saturn, Uranus and Neptune, and discuss the actual constraints we have on those models, in particular on the quantity of "heavy elements" (elements other than hydrogen and helium) in the planet, and on the possible presence and mass of a dense inner core. These constraints on the present interior structures will be turned into constraints on giant planet formation theories by using our (limited) knowledge of their past evolution, most importantly of the dominant transport processes in the planets. The consequences for solar and extrasolar giant planet formation will be discussed.

MIGRATION OF PLANETESIMALS AND PLANET EMBRYOS DURING THE PROCESS OF PLANET FORMATION

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Computer simulation of the evolution of disks that originally consisted of hundreds of gravitating solid bodies orbiting the Sun was made. The obtained results show that each of the terrestrial planets incorporated planetesimals from all feeding zones of these planets. Up to 10 % of bodies can be ejected into hyperbolic orbits from these zones. The embryonic masses of the unformed terrestrial and giant planets may have exceeded $0.1m_{\oplus}$ and $m_{\oplus}$, respectively, where $m_{\oplus}$ is the mass of the Earth. The time to form 80 % of the Earth's mass may not exceed 10 Myr. The total mass of bodies ejected from the zones of the giant planets into hyperbolic orbits may have been ten times as large as the mass of bodies that entered into the planets. The embryos of Uranus and Neptune with initial masses close to the present masses of these planets may have originated near the orbit of Saturn and then, due to the interaction with migrating planetesimals, may have migrated to the present distances from the Sun moving all time in nearly circular orbits. Jupiter could decrease its semimajor axis by 0.5 AU. It could incorporate more ices and rocks than any other planet. Both, local beyond-Neptune planetesimals and those ejected from the feeding zone of the giant planets, could form the Edgeworth-Kuiper belt. This work was supported by the Russian Foundation for Basic Research and the Russian Federal Program "Astronomy".

RADIATION PRESSURE ON DUST AGGREGATES IN CIRCUMSTELLAR DISKS

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Circumstellar dust particles play an important role in the formation of planetesimals and conversely are maintained by the supply from planetesimals in a circumstellar disk. One of the key parameters to estimate the dust distribution in a disk is the radiation pressure force acting on circumstellar dust. We study the ratio of radiation pressure to gravity on circumstellar dust particles as a function of size. The ballistic particle-cluster and cluster-cluster aggregations are applied to model the particle's shape and structure. We assume that the aggregates consist of spherical monomers of identical size and material composition. The radiation pressure cross sections are calculated using the discrete dipole approximation. We show that the radiation pressure on an aggregate having submicron radius is weaker than that on a volume-equivalent sphere. Therefore fluffy porous dust particles with submicron radii have a larger lifetime, compared to compact spherical particles. As a further consequence, the size limit for particles that can stay in bound orbits around the star shifts, when we assume porous dust particles. We also show that the radiation pressure perpendicular to the wave vector of the stellar radiation can reach about 10 % of the parallel component for dielectric submicron aggregates. Hence when a fluffy porous dust particle rotates randomly, the perpendicular component may yield a random motion along the trajectories of the particle.

THEORIES OF GIANT PLANET FORMATION

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An overview of current theories of planetary formation, with emphasis on giant planets, is presented. The most detailed models are based upon observations of our own Solar System and of young stars and their environments. While these models predict that rocky planets should form around most single stars, the frequency of formation of gas giant planets is more difficult to predict theoretically. Terrestrial planets are believed to grow via pairwise accretion until the spacing of planetary orbits becomes large enough that the configuration is stable for the age of the system. Giant planets begin their growth as do terrestrial planets, but they become massive enough that they are able to accumulate substantial amounts of gas before the protoplanetary disk dissipates. Most models for extrasolar giant planets suggest that they formed as did Jupiter and Saturn (in nearly circular orbits, far enough from the star that ice could), and subsequently migrated to their current positions, although some models suggest in situ formation.

PS12

SOLAR SYSTEM DUST BEYOND THE ASTEROID BELT

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The observation of dust debris disks around mainsequence stars raises the question to what extent they are comparable to the solar system dust cloud. Most of the observed disks cover a region which corresponds to the region of the Kuiper belt in our solar system. However, our recent knowledge of the outer solar system dust cloud is limited to the region between the asteroidal belt and Jupiter mainly, but may allow for some estimates of the dust cloud beyond that. We discuss the radial gradient of the zodiacal light brightness measured with the photopolarimeter on the Pioneer 10 and 11 spacecraft as they traveled from 1 to 5 AU and compare these measurements to estimates of the thermal emission that could stem from an outer solar system dust cloud. We finally compare these results to local dust fluxes measured on Pioneer 10/11 as well as on Ulysses, which however, are in a different size interval of particles.

WHAT CAN WE LEARN FROM EXTRASOLAR GIANT PLANETS?

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Photometry and spectroscopy by next-generation instruments of extrasolar planets will reveal a great deal about the character of these objects and about planetary processes operating in new conditions. We will report on observational tests for atmospheric temperature, gravity, and condensation derived from over 50 radiative-convective equilibrium models of extrasolar giant planet (EGP) atmospheres. The near-infrared emitted and reflected flux is strongly dependent upon the presence or absence of condensates, upon their grain size distribution, and their vertical extent. In the cold atmospheres of the solar giant planets condensates form distinct cloud layers. Conversely in cool stellar atmospheres condensates are apparently mixed over a substantial vertical extent. Broad band visible and near-IR EGP photometry will thus provide interesting new information on condensate formation and mixing in intermediate-temperature planets. Spectroscopic detection of CH_4, NH_3, and CO will constrain atmospheric temperature and vertical mixing. In both Gl 229 B and Jupiter vertical mixing brings substantial non-equilibrium amounts of CO to the visible atmosphere. Measurements of the CO abundance for a suite of planets as a function of g and $T_{\rm eff}$, will provide powerful new constraints on the efficiency of vertical mixing and the formation of detached convection zones, as postulated for Jupiter and perhaps observed in Gliese 229 B.

SEARCH FOR AN EXTENDED EXOSPHERE AROUND 51 PEG B WITH ISO

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Observations of periodical Doppler-shifts in the spectrum of 51 Peg have led to the proposal of a planet (51 Peg B) orbiting its star at only 0.05 AU distance (Mayor and Queloz, 1995). However, to clarify the exact nature of the planet it is of increasing importance to confirm its existense by independent methods. It seems likely that the planet around 51 Peg it is a large gas giant, similar to Jupiter. We expect a significant evaporation of its atmosphere due to thermal/non-thermal escape and/or gravitational mass loss, forming a large enveloppe surrounding the planet and partially occult the star (orbit inclination close to 90°). We have searched for absorption features of ions/molecules of this enveloppe in the near-IR spectrum (2.4 μm to 3.5 μm and 4.6 μm to 4.8 μm) of 51 Peg during transit of its planet using the short-wavelength spectrograph (SWS) on the Infrared Space Observatory (ISO). First analysis of these observations will be presented.

SEARCHING FOR PLANETS WITH THE COROT SPACE MISSION

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The space mission Corot will be launched in 2001 with the scope of monitoring the flux of thousands of stars with a very high photometric accuracy, during several periods of 150 jours. One of the objectives of Corot is the detection of extra-solar planets by looking for transits of planets in front of the disk of stars. Corot accomodates a 25 cm telescope with low straylight, and 2 × 2048 × 2048 CCDs that will allow to monitor 5000 to 12000 stars simultaneously up to the 16th magnitude. The stability and noise performances should make easy the detection of Jupiter's like planets and possible the detection of Earth-like planets with radius $> 1.4 R_\oplus$. Under study is a dispersive system that will allow to retrieve some chromatic information : this could be essential to discriminate actual events against stellar fluctuations that would mimic a transit The mission, the instrument and the results of simulations will be presented, together with a discussion on the number of expected events: the multiple ones with a periodic signature, or the single or double events with a (a)chromatic signature. The later ones may lead to the discovery of planets in the *habitable zone*.

HOW TO SEARCH FOR RINGS AND SATELLITES OF EXTRA-SOLAR PLANETS

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After the first discoveries of extrasolar planets, a step further consists in the search for their moons and rings. In the Solar System, 4 planets have giant satellites and one of them has a bright ring. It would be interesting to know if this is a general trend in other planetary systems. Extra-solar moons are also of particular interest for exobiological purposes: it has recently been suggested that 'life' can also develop on satellites of these giant planets. Unfortunately their detection, requiring a kilometer-sized interferometer in space to get an image, seems to be so far away in the future that this suggestion cannot go beyond an interesting speculation. Here we show that the detection of giant moons and of rings of giant planets is nevertheless possible with present techniques by the study of their transits and of their brightness variation along the planet orbit. For planets in very close orbits, giant rings can be detected by precise infrared photometry or interferometry.

GEOMETRIC ALBEDO MODELS OF EXTRA-SOLAR PLANETS

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We have computed the geometric albedo spectrum for over fifty different extra-solar planet model atmospheres with temperatures ranging from 100 to 1200 K and gravities between 22 to 3000 m sec^{-2} ($1 < M < 70\,M_J$). The geometric albedo is computed as a function of wavelength and we include all the opacity sources H_2-H_2, H_2-He, CH_4, NH_3, H_2O and CO computed for the thermochemical equilibrium abundance. We also account for Rayleigh and Raman scattering, and some models include water and silicate clouds. We find that Rayleigh scattering causes the geometric albedo to be very bright in the blue region from 0.3 to 0.6 microns. Beyond 0.6 microns extra-solar planets will be dark in reflected light for effective temperatures between about 500 to 1000 K. At lower temperatures the presence of a water cloud will significantly brighten the spectra beyond 0.6 microns. Silicate clouds will darken the planet at all wavelengths. For cloud free atmospheres there does not appear to be a strong correlation between the geometric albedo and temperature, while there is a gravity dependence. We also find that the geometric albedo falls off very rapidly in the near infrared, where these objects are much darker than previously suspected. These results are relevant to efforts at imaging extra-solar planets.

THE FORMATION OF THE SOLAR SYSTEM

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Proceeding from the supposition that the collapse of the protocloud could be accompanied by waves of different nature, the hypothesis is put forward which consider the cosmic bodies populates the solar system as the product of the wave parametric resonance interaction. A schematic model of the phenomenon which permits to connect the wave parameters with the observable characteristics of planets and satellites. Some consequences connected with the existing anomalies in the solar system structure are indicated. It has been shown that the formation of planets was sequentially in time. Time scale for the planets is ca. 1000 years. Time scale for the satellites is ca. million years.

ON MOVEMENT OF THE CONTINENTS

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It is known that there exist incontestable evidences of the past and actual movement of the continents [1]. Various processes enabling to cause this phenomenon are discussed [2]. The hypotheses corresponding the movement of the continents with the processes proceeding in the upper Earth mantle seem to be the most reliable. In particular, one cannot exclude that the observed tectonic activity of the Earth is caused by water. The water covers 70 per cent of the Earth's area and it is related to the most mobil and active reagents which enable to stimulate essential changes in the strata. In this light, the water accumulation on the Earth's surface is a principal problem in understanding the tectonic phenomena that could be related to the inner horizon hydratation developing up to now. On the other hand, the geological studies have revealed the periodicity of the tectonic activity begining from the moment postponed at 4 Gyears ago. It seems we deal with a certain transition process which acts up to now. This process could start due to a collision of the Earth with a cosmic body consisting predominantly of the supercooled ice at the moment indicated above. In result of the inelastic shock, a greater part of the water (in the form of ice) occured to be in the region of the Pacific Ocean with the Moon being separated from the opposite side. Further processes were washing out of the carbon dioxide from the Earth's atmosphere with further carbonates accumulation, and the ice/water re-distribution over the Earth's surface leading to the starata hydratation and to beginning of the continent moving mechanism. Thus the actually observed phenomenon could be a consequence of the evolution of the Solar system as a whole [3]. Taking into account this circumstance one could avoid some difficulties when analyzing the processes taking place on the Earth's surface at present.

GROWTH OF A MIGRATING PROTOPLANET

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In the solar nebula, protoplanets rapidly migrate to the sun due to the tidal interaction with the nebula(e.g., Ward 1986, Icarus 67, 164-180). We investigated the growth of a migrating protoplanet. The accretion rate of planetesimals to the protoplanet strongly depends on the orbital elements of planetesimals (e.g., their eccentricities and inclinations). We directly calculated the orbital evolutions of 2000 planetesimals in the vicinity of the migrating protoplanet and obtained the accretion rate by counting the number of collisions with the protoplanet. In our simulation, the migration speed of the protoplanet is a parameter. For various values of the migration speed, we performed simulations and obtained the accretion rate as a function of the migration speed. As a result, we found that the accretion rate becomes large with an increase in the migration speed. The comparison of the obtained accretion rates with that of the case with no migration showed that the rapid migration of a protoplanet enhances the accretion rate by more than the factor 10. This enhancement of the accretion rate may make it possible that planets is formed before they fall to the sun due to the tidal interaction with the solar nebula.

MIGRATION AND EVOLUTION OF EXTRASOLAR PLANETS

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The recent discoveries of extrasolar planets at a wide range of heliocentric distances have raised questions of giant planet migration. Giant planets can migrate from their formation locations at several AU. Inward migration is caused by angular momentum exchange with the circumstellar disk. When a planet gets close to its central star, tidal bulges raised on the central star can slow a planet's inward migration. Still closer to the star, Roche lobe overflow and planetary mass loss can occur. We show that after migrating, some planets can survive at small heliocentric distances, and some at more modest heliocentric distances, thus reproducing the observed distribution of extrasolar planets and also Jupiter. The final heliocentric distances and masses of giant planets depend on the characteristics of the protostellar nebula. We will also discuss interactions of the young star's strong stellar wind with planets at small heliocentric distances. Lastly, we will discuss the predicted distribution, based on our planetary migration model, of giant planets around normal stars.

MASS AND HEAT TRANSFER RELATED TO INFALL OF THE ENVELOPE ONTO THE PROTOPLANETARY DISK

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We consider infall of material from the envelope onto the protoplanetary disk at the stage of protosolar collapse. We calculate the location z_b of the boundary layer between the envelope and the disk ($z_b \approx 3$ scale heights), the thickness of the layer and the turbulent viscosity in it. The radial dependence of mass flux onto the disk is found to be essentially different from that for infinitely thin disk. The radial damping length for the material subjected to viscous stresses in the boundary layer is $\sim r_e$ (the radius of entrance into the layer). In a time of collapse the mass flux onto the protosun due to turbulent viscosity in the boundary layer is $\sim 10^{-4}$ of disk mass and therefore is insignificant for total mass transport in the disk. The calculated values of Ma show that a shock front exists above the whole disk. The heating of the disk due to radiation from the shock front is evaluated to be much lower then heating by radiation of optically thick envelope and viscous heating in the disk.

PS13 Mars Pathfinder Mission: Update

Convener: Keller, H.U.
Co-Conveners: Golombek, M.P.; Wänke, H.

Laboratory Spectrophotometric Measurements of Mars Analog Materials and Implications for the Data Evaluation of the Imager for Mars Pathfinder (IMP).

G. Arnold, A. Dummel, P. Lampen, F. Trauthan (DLR, Institut für Planetenerkundung, Berlin, Germany), P. Smith and D. Britt (University of Arizona, Lunar&Planetary Laboratory, Tucson, Arizona, USA), J. R. Johnson (U.S.G.S., Flagstaff, Arizona)

Laboratory reflectance spectra of Mars analog materials have been analyzed at IMP wavelengths (400-1000nm) for relevant observation, illumination and azimuth angles using the DLR-Gonio-Photometry-Laboratory (GPL). Ferric oxides, different clay minerals, palagonitic soils in different particle size fractions and some mixtures of these materials were used to simulate the spectrophotometric behavior of Martian dust and sand weathering products observed at the Pathfinder landing site. The spectrophotmetric measurements of particulate Mars analogs at different phase and azimuth angles show that at phase angles below 40° an increase of reflectance with decreasing particle size takes place (opposition effect). This effect depends on the particle size, the phase and the azimuth angle. The photometric equator images of IMP are covering phase angles from 0 - 155° (Johnson J. R., (1997), AGU, P22A-07). In order to discuss the implications for the IMP data evaluation the surface normals and phase angels for two IMP target areas are calculated from a DTM. The influence of phase angle variations on the surface brightness is discussed for different IMP wavelengths.

MORPHOLOGICAL CHARACTERISTICS OF SEVERAL ROCKS WITHIN AND NEAR THE ROCK GARDEN: PATHFINDER LANDING SITE, MARS

A. T. Basilevsky (1), W. J. Markiewicz (2) and H. U. Keller (2)
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Several rocks within the Rock Garden locality at the Pathfinder landing site have been studied. Rocks Chimp, Half Dome, Moe, Stimpy, and Flat Top, all comparable in size with rover Sojourner (32x47x62 cm), as well as several smaller rocks were examined for their 3-D properties from stereo images taken by the lander and rover cameras. The maximum resolution of the analyzed images of about 0.5-0.8 mm/pixel allows to study the rocks and soils with unprecedented detail. The rocks' surface texture vary from rock to rock from massive with surface pits and flutes (e.g. Moe) to highly pitted or vesicular (Chimp). The pits and/or vesicles typically have very sharp edges. Some rocks show fractures, prominences, and dents with edges and points that are also very sharp. If we ignore the effect of dust mantling on the tops of some of the rocks, the sharpness of the rocks micro relief does not vary as the position from the base of the rock. We consider these observations as evidence of lack of significant eolian abrasion of the studied rocks' surfaces. Number of small rocks does not seem to be greater near the base of larger rocks than in general scenary, indicating that the majority of the small rocks are not the result of the in-situ destruction of the larger ones. We did not find in the studied images any good candidates for pebble-bearing conglomerates. This may be, however, due to the incompleteness of our ongoing study.

RIGOROUS LEAST SQUARES ADJUSTMENT OF IMAGER FOR MARS PATHFINDER PANORAMIC STEREOBUNDLE BLOCK

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The paper describes the digital and analytical photogrammetric process for a rigorous adjustment of IMP stereoimage data constituting a full 360 degree panoramic mosaik. The mathematical approach assumes rigid yet not exactly known interior (calibration) and relative orientations (pose) of the stereocamera and approximate exterior orientation of the IMP camera head. The photogrammetric panoramic block consists of a set of images overlapping each other both in azimuthal and vertical direction. In the overlapping zones between adjacent images, tiepoints have been measured automatically on a digital photogrammetric softcopy workstation to subpixel accuracy. The mathematical model for the IMP stereobundle configuration is briefly described. The panoramic block has been adjusted simultaneously for all stereoimages by means of a modified version of the program package CAP originally developed for industrial close-range applications. The final results yield a highly qualitative, precise and consistent set of adjusted orientation parameters for all images of the mosaik, and are prerequisite for the derivation of a seemless stereopanorama.

DOES THE PATHFINDER VALUE FOR THE MOMENT OF INERTIA FACTOR IMPLY A NON-CHONDRITIC FE/SI RATIO OF MARS?

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The APXS-measurements of the Pathfinder (MPF) mission confirmed the high =46eO content in the martian mantle as estimated by Dreibus & W=E4nke (DW) (1984) using data from martian meteorites (SNC's). According to the DW Mars model, Mars formed with 40 % CI material (component B), the rest being volatile depleted highly reduced matter (component A). Assuming a chondritic Fe/Si ratio for the whole planet and assuming all the sulfur to have entered the core, a core mass of 21 % of the planet mass was obtained containing 14 % S. This leads to a moment of inertia factor (I/MR2) of 0.355 =B1 0.002 (Bertka & Fei (1997) and Sohl & Spohn (1997)). The MPF mission has provided a new value for I/MR2 of 0.3662 =B1 0.0017 (Folkner et al. (1997), which, if correct, could mean either a smaller or less dense core (Sohl & Spohn, 1997) or a denser mantle (higher FeO) (Bertka & Fei, 1997). Both models predict a non-chondritic Fe/Si ratio for the whole planet. One possibility to preserve the chondritic Fe/Si ratio is to reduce the mean density of the core by having, beside S, a further light element in the core. For example, 40 % CI matter would add 1.4 % carbon to the planet, resulting in 5.6 % carbon in the core. Another possibility is H. Both H and C have been postulated by Zharkov (1996) to have entered the core of Mars. In light of the scarcity of C-compounds on the martian surface as well as in martian meteorites, it would make sense that C has dissolved in the core to a large extent.

PRECISION CARTOGRAPHIC MAP OF THE PATHFINDER LANDING SITE

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Viking Orbiter images were reprocessed using new techniques to produce a precision controlled, photomosaic map of the Mars Pathfinder landing site prior to landing. The difference between the Mars-fixed coordinates of the lander as determined from the precision cartographic map product and that determined from earth-based radio tracking of the lander (Falkner, 1997) are essentially zero, within the accuracy of the radio tracking solution. The precision cartographic map product was produced from measuring a totally new control network of 586 points, local to the landing site, observed in 50 Viking Orbiter images. Mars-fixed areocentric coordinates of latitude, longitude and radius for each control point together with special camera pointing parameters and orbit parameters were estimated in the block adjustment, typically not estimated in previous cartographic efforts. Convergence angles of typically 40 deg and as large as 90 deg for the control points were achieved in the highly over determined system of observations. No tie was made to the nearby Viking 1 landing site and special data weighting was employed to produce the map which was tied to the digital terrain model derived from the dense control network.

ON PROBLEM OF ENRICHMENT IN ^{13}C OF THE MARTIAN CARBON

E. M. Galimov (V. I. Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Kosygin Street 19, Moscow 11975, Russia)

SNC-meteorites are known to have unusual $^{13}C/^{12}C$ isotope composition. The fact that both martian carbonates and CO_2 of the atmosphere are inriched in ^{13}C ($\delta^{13}C$ +30 - +40 ‰) is evidence that this is a global scale martian phenomenon. The concept is developed that the ancient martian atmosphere was reduced and dominated in CH_4. The CO_2 component of such an atmosphere ought to be enriched in ^{13}C due to thermodynamic isotope effect in CH_4-CO_2 isotope exchange system. If the methane component was largely lost by Mars while isotopically heavy CO_2 was retained, the whole martian surface carbon reservoir would become isotopically heavy. It is suggested that reduced atmosphere is a common characteristic of planets on their early stage. In contrast to Mars the Earth retained both CH_4 and CO_2 and consequent oxidizing of CH_4 led to the "normal" isotope composition of the Earth crust carbon reservoir.

PHOTOGRAMMETRIC ANALYSIS OF FAR-FIELD IMP IMAGES

B. Giese, J. Oberst, F. Trauthan, R. Jaumann (DLR, Institute of Planetary Exploration, Rudower Chaussee 5, 12489 Berlin, Germany)

We performed a photogrammetric analysis of IMP images from stowed and deployed camera positions to map the far-field (> 50m) terrain of the Mars Pathfinder landing site. Combining images from stowed and deployed camera positions instead of left- and right eye images increases the stereo baselength from 15cm to 61cm thus improving any measurements of distance greatly. We first adjusted the azimuth and elevation angles of the involved images using a photogrammetric bundle block adjustment. This is necessary because the commanded camera pointing angles are accurate to about 1 degree only. On the basis of the adjusted pointing angles, we then obtained the coordinates of distant (≈ 100m) target object points with accuracies of some meters. To enhance the reliability of the crucial image point coordinates, measurements were carried out on a digital photogrammetric workstation using state-of-the-art software. Results of this study may ultimately be applied to determine sizes of rocks in the background of Pathfinder images and thus to extend measurements of the size-frequency distributions (Hauber et al., this meeting) to larger sizes.

THE MARS PATHFINDER MISSION AND SCIENCE RESULTS

M. P. Golombek and M. P. Golombek
Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109.

Mars Pathfinder successfully landed on the surface of Mars on July 4, 1997, deployed and
navigated a small rover, and collected data from 3 science instruments and 10 technology experiments. The mission operated for 3 months and returned 2.6 Gbits of new
data, including over 16,000 lander and 550 rover images, 16 chemical analyses of rocks and soil,
and 8.5 million individual temperature, pressure and wind measurements. The mission captured
the imagination of the public, garnered front page headlines during the first week, and became
the largest internet event in history. Chemical analyses indicate some rocks may be high in
silica implying differentiated parent materials. Rounded pebbles and cobbles and a possible
conglomerate suggest fluvial processes that imply liquid water in equilibrium with the atmosphere
and thus a warmer and wetter past. The moment of inertia indicates a central metallic core
of 1300-2000 km in radius. Composite airborne dust particles appear magnetized by freeze dried
maghemite stain or cement that may have been leached from crustal materials by an active
hydrologic cycle. Remote sensing data at a scale of generally greater than 1 km and an Earth
analog correctly predicted a rocky plain safe for landing and roving with a variety of rocks
deposited by catastrophic floods that are relatively dust free.

ASSESSMENT OF MARS PATHFINDER LANDING SITE PREDICTIONS

M. P. Golombek (1), A.F.C. Haldemann (2), H.J. Moore (3), T.J. Parker (4), J.T. Schofield (5) and M. P. Golombek (1)
(1,2,4,5) Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109, (3) U.S. Geological Survey, Menlo Park, CA 94025.

The Mars Pathfinder lander came to rest on a rocky depositional plain in Ares Vallis with
characteristics that were predicted from remote sensing data at a much coarser scale prior to
landing. Delay-Doppler radar predicted the elevation of the site to be within 100 m of Viking
Lander 1 with respect to the 6.1 mbar geoid, which is confirmed by tracking results.
Assumed atmospheric conditions were well within the entry, descent and landing design. The
gently undulating surface around the lander is consistent with radar root-mean-square slopes near
5. Rock abundance from Viking orbiter thermal data and estimates of the area covered by
potentially hazardous rocks higher than 0.5 m are similar to that measured at the landing site.
Radar reflectivity and thermal inertia indicated the surface was safe for landing and roving. Color
and albedo data suggest Ares Vallis to be relatively dust free, which is borne out by the
dark-gray rocks at the site. Finally, the Ephrata Fan, an Earth analog in the Channeled Scabland in
Washington, compares favorably with the moderately rocky depositional plain near the mouth of
Ares Vallis.

PLEASE CORRECT THE SESSION ON THE FOLLOWING ABSTRACT SUBMITTED BY R GREELEY TO PS13 MARS PATHFINDER. THANK YOU. -B ERWIN (FOR GREELEY)

MARS PATHFINDER LANDING SITE: WIND-RELATED FEATURES.

Ronald Greeley, Robert Sullivan, Michael Kraft (Arizona State Univ.); Peter Smith (Univ. Ariz.); Michael Malin (Malin Space Sci. Sys.); Ruslan Kuzmin (Vernadsky Inst-Russian Acad. Sci.); M.P. Golombek, Ken Herkenhoff (JPL)

A variety of features attributed to aeolian processes are identified at the Mars Pathfinder (MPF) landing site including dust settled from the atmosphere on rocks, wind-sculpted drift deposits, dunes, ventifacts, and ripplelike patterns. These features suggest the presence of sand-sized (>60 micrometers) grains capable of saltation and abrasion. The orientations of MPF aeolian features suggest winds blowing toward the 217 deg azimuth. This compares with an average azimuth of 213 deg for bright wind streaks seen on Viking Orbiter images near the site, and General Circulation Model predictions of strongest winds blowing toward 209 deg azimuth in northern winter. The orientations seen on IMP images of the 3 wind socks indicate wind direction and magnitude. The wind socks measured gentle winds ~10 m/sec from the south-southwest, consistent with the predictions of the GCM. The 3 wind socks enable surface wind shears and the surface roughness parameter to be determined, which are critical for understanding aeolian processes.

MARS PATHFINDER LANDING SITE: WIND-RELATED FEATURES.
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GCM SIMULATIONS OF THE MARS PATHFINDER ASI/MET DATA

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Mars Pathfinder successfully landed in the Ares Vallis flood plain (19.3°N, 33.6°W) on July 4, 1997. The spacecraft carried a suite of instruments to record the structure of the atmosphere during the entry, descent, and landing as well as for monitoring meteorological phenomenon while on the surface. Collectively, these instruments are known as the ASI/MET experiment (Atmospheric Structure Investigation / METeorology). To help interpret these data we have carried out set of experiments with the same version of the NASA/Ames Mars General Circulation Model (MGCM) that was used to predict meteorological conditions for the Pathfinder mission (Haberle et al., *J. Geophys. Res.*, **102**, 13,301-13,311, 1997), but with the following upgrades: (1) a higher model top (~100 km), (2) an approximate treatment of non LTE effects for solar radiation, and (3) a new boundary layer scheme based on a modified version of the "level 2" theory of Mellor and Yamada (*Rev. Geophys.*, **20**, 851-875, 1982). This upgraded version is better able to simulate the entry data, as well as the landed meteorology data.

ROCK STATISTICS AT THE MARS PATHFINDER LANDING SITE

A. F. C. Haldemann (1), R. C. Anderson (1), N. T. Bridges (1), E. Hauber (2), R. Jaumann (2) and M. P. Golombek (1)
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A population of some 2000 rocks was measured at the Pathfinder landing site using the NASA Ames Marsmap virtual reality system during the first 6 weeks of mission operations. Rocks in the far-field were also measured directly using the stereo base afforded by the Imager for Mars Pathfinder, with views from before and after deployment on its mast. Rock frequency and size distribution statistics are consistent with remotely sensed data, and with Earth analog sites. A database containing the rock set is being used for further analysis of rock shape, colour and burial. Study of this database may elucidate whether, and to what extent, distinct rock populations are present at the MPF site.

THE ROCK POPULATION AT THE PATHFINDER LANDING SITE

E. Hauber, R. Jaumann, C. Mosangini, N. Russ, K.-D.Matz and F. Trauthan
(DLR, Institute of Planetary Exploration, Berlin) and the Patfinder Imaging Team

On July 4th 1997, the Mars Pathfinder landed in Chryse Planitia at the northern end of the outflow channel Ares Vallis (19.33°N, 33.55°W). Until September 27th 1997, more than 16,000 images of the stereo camera on the lander and 550 images of the rover camera were transmitted to Earth. They show a slightly undulated surface, covered by rocks of different size and shape. The areas between rocks and partly the rocks themselves are covered by fines, most probably dust. Since the size distribution of material can be used to place constraints on sediment emplacement mechanisms, the visual width of rocks, their height, and their position were measured in the stereo images. Additionally, an algorithm was developed to distinguish automatically between rocks and soil, making use of the blue/red ratio of color filters and the height information in a digital elevation model. The results were compared to the size distribution of material at the landing sites of Viking-1 (also in Chryse Planitia) and Viking-2 (Utopia Planitia) and to rocky terrestrial sites thought to be analogous to Mars (Death Valley, Iceland). Though Pathfinder landed in a similar geologic setting as Viking-1, the size frequency distribution of rocks is closer to the values found at Viking-2 which landed on the ejecta material of a nearby crater. On average, 12-16% of the surface is covered by rocks larger than a few centimeters in diameter, whereas locally this value can reach 30%. Very similar results were found at terrestrial sites, e.g. at the abandoned alluvial fan Mars Hill in Death Valley.

Photometry of Selected Materials at the Mars Pathfinder Landing Site

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Three imaging sequences obtained from a variety of surface regions over a wide range of phase angles have been obtained by the IMP camera onboard the Mars Pathfinder lander. These photometric data sets consist of (1) three small scenes located approximately north, south, and west of the lander ("photometric spots"), and (2) two image strips composed of three images each, located along the anti-sunrise and anti-sunset lines ("photometric equator") extending from near the lander to near the horizon; and (3) the large rock "Yogi." The photometric spot images were obtained in six filters (443, [480 or 860], 531, 671, 752, and 967 nm) at five times of day (0700, 0830, 1200, 1530, and 1700 LST) covering phase angles from 20-150 degrees. The photometric equator images were obtained in three filters (443, 752, 967 nm) at four times of day (0800, 1200, 1600, and 1700 LST) covering phase angles from ~0-155 degrees. The Yogi images were obtained in four filters (443, 531, 671, and 967 nm) at three times of day (0740, 1500, 1640 LST) over Sols 55 and 56 and at 0900 LST on Sol 75. Local surface facet orientations derived from stereo models will be used to improve the accuracy of photometric functions for individual rocks and soil surfaces. Preliminary phase functions extracted from these data exhibit increasing reflectance at lower phase angles, indicating a dominantly backscattering photometric function, although instances of forward-scattering at large phase angles are also present. Specular scattering geometries may explain some abnormally high reflectances that have hampered preliminary photometric modeling efforts. Further refinement of the calibration methods will also increase the precision of these measurements.

THE MAGNETIC PROPERTIES OF THE MARTIAN DUST AS STUDIED ON THE MARS PATHFINDER LANDER.

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Two magnet arrays were mounted on the Mars Pathfinder lander. Each array consists of five "bull's-eye" magnets constructed to ensure a high variation of the strength of the magnetic field – and field gradient – at the surface of the instrument. Besides the magnet arrays the Pathfinder lander carried a tip plate magnet. The tip plate magnet is placed about 7 cm from the eye of the camera, and was imaged through a diopter lens to increase resolution.

These instruments were exposed to the dust suspended in the Martian atmosphere. As well the magnet arrays as the tip plate magnet attracted dust. The magnet arrays were imaged through the various filters of the Imager for Mars Pathfinder (IMP). The results obtained will be discussed.

Some of the SNC-meteorites contain a ferrimagnetic phase, titanomagnetite. Is there a direct connection between the magnetic properties of the Martian surface rocks and the magnetism of the soil on Mars? Some aspects of the history of the Martian soil, i.e. its formation and possible evolution are recorded in the magnetic phase in the soil.

TURBULENCE MOMENTS AND SPECTRA IN THE MARTIAN ATMOSPHERIC SURFACE BOUNDARY LAYER.

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During the ASI/MET experiment of the Pathfinder mission turbulence data were systematically sampled at 1 Hz allowing evaluation of statistics of turbulence spectra and moments for different atmospheric conditions. Here, we focus on analysis of the temperature and wind direction signals. The statistics is stratified by the thermal stability of the atmosphere (the Monin-Obuchov scale) and wind speed classes. Since there is presently most confidence in interpretation of the temperature signals, we use the moments of temperature turbulence and the temperature profiles to estimate the stability conditions. The turbulence moments and spectra are shown to scale satisfactorily with the scaling parameters of the Monin-Obuchov formulation. To assess the atmospheric variables better, we have tried as well correct the variables for the flow distortion by the Lander body and the near lander orography.

SURFACE MORPHOLOGY AT THE PATHFINDER LANDING SITE.

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The morphology of the Pathfinder landing site shows small elongated ridges. These ridges extend to the horizon. Within a radius of app. 100 m the Imager for Pathfinder (IMP) camera provided stereoscopic information. Photogrammetric analysis of images were carried out to obtain a digital terrain model and to map ridges and troughs within this radius. Panoramic images were inspected on stereoscopic screens to help in the identification of ridge crests by the human eye. Coordinates have been measured for about 2000 ridge crest points. Ridges were found to have wavelengths of about 10-20 m and elevations of 1-3 m on average. Maps of the ridge crest points show that ridges and troughs are generally oriented from SW to NE, with minor lineaments oriented from S to N and SE to NW. The dominant SW to NE directions is consistent with the Tiu Vallis direction of mass transportation; the S to N and NW to SE directions fit with the main orientations of Ares Vallis. These three directions of material transportation at the end of Are and Tiu Valles can be identified in Viking orbiter images by those streamlined islands which have been eroded by both channels. Crater counts show Ares Vallis to be older than Tiu Vallis. Tiu Vallis material has to some extent modified the pre-existing Ares Vallis materials but the last deposition events of both channels are still visible, suggesting that deposition was the major geological process in this area.

Mapping the Sagan Memorial Station Site with the IMP Camera

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The Imager for Mars Pathfinder (IMP) obtained five panoramic image sets that permit detailed mapping of the landing site out to tens of meters the spacecraft. We have constructed a 3D control network of the site from points measured in the losslessly compressed images and registered the other images to this network to construct seamless panoramic mosaics. We have also used automated stereo-matching techniques to construct a digital terrain model (DTM) that will be used to generate 1) panoramic mosaics in 15 filter bands, with parallax between the two cameras removed; 2) orthorectified mosaics in planimetric view; and 3) contours of elevation and range. Distribution plans for these products will be described and examples shown. Photometric modeling using the DTM may also make it possible to produce spectral datasets precisely corrected for the subtle variations of solar and sky illumination, and DTMs with pixel-scale detail added by photoclinometry. Interactive stereomatching may permit mapping of selected landforms to ranges of hundreds of meters from the spacecraft.

IMAGER FOR MARS PATHFINDER OBSERVATIONS OF AEROSOL STRUCTURE: TWILIGHT, CLOUDS, AND DUST

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During July and August 1997, images from the Imager for Mars Pathfinder (IMP) allowed three types of observations that probe the vertical structure of the aerosols (either dust or ice clouds). First, twilight persists more than two hours before sunrise (or after sunset). Second, clouds are present during the two hours before sunrise. Third, the extinction of sunlight when the Sun was at very low elevations (<10°) varies from day to day. The brightness of the twilight 2 hours before dawn probes the haze not just locally (at Ares Vallis) but also regionally, because the sunrise terminator is 1700-km distant. The twilight brightness is a function of aerosol properties (measured independently) and of the haze structure. A spherical-shell-atmosphere, Monte Carlo-type scattering model has been developed and tested and will be used to constrain the vertical structure of the dust (specifically the scale height and the presence of layers). The extinction of the Sun as it sets or rises also constrains the scale height and/or the presence of layering. Using the model results, the contrast and timing of the cloud observations will be used to constrain the elevation and physical properties of the clouds. Preliminary analysis of the images has suggested that the scale height is near 13 km, that there are discrete layers on at least some days, and that the observed clouds are small particles below 25-km altitude.

THE MAGNETIC PROPERTIES INSTRUMENTS ON MARS PATHFINDER. POSSIBLE USE IN FUTURE MISSIONS

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The Mars Pathfinder lander carried three different types of magnetic properties instruments. Two magnet arrays, one tip plate magnet and two ramp magnets. All these instruments captured air-borne magnetic dust. From images of the patterns of dust accumulated on the magnet arrays and the tip plate magnet, the saturation magnetization of the magnetic dust grains has been estimated. A magnet array and a tip plate magnet are also part of the MVACS payload in the Mars Surveyor 1998 mission.

The ramp magnet was designed to collect a magnetic fraction of the dust to be analysed by the APX-spectrometer of the micro-rover. This instrument was imaged, but unfortunately contact with Mars Pathfinder was lost just before this analysis was planned to be made. The science objectives of this experiment will be described – and the importance of the experiment will be explained.

Similar experiments are recommended for future missions, particularly as supplements to Mössbauer and APX spectrometers.

THE COLOUR OF THE MARTIAN SKY AND ITS INFLUENCE ON THE ILLUMINATION OF THE MARTIAN SURFACE

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The optical depth of the atmosphere during the first months of Mars Pathfinder mission was measured by Imager for the Pathfider (IMP) to be about 0.5 in the visible. The atmospheric scattering and extinction of solar photons is due to aerosols and leads to a reddening of the sky. The diffuse sky brightness produced by the scattering contributes significantly to the total illumination of the surface. The difference in spectrum of the direct solar and the diffuse sky illuminations effects the apparent colour of rocks, soil and any other imaged surface as a function of optical depth of the atmosphere, solar zenith angle and surface topography. Images obtained through various geological filters at various time of day are discussed illustrating the strength of this effect. Radiative transfer within the modeled Martian atmosphere is used to understand the diffuse contribution to the spectral characteristics of the surface images. Models are compared with images of the calibration target and sky itself.

OPTICAL PROPERTIES OF THE MARTIAN AEROSOLS AS DERIVED FROM IMAGER FOR MARS PATHFINDER MIDDAY SKY BRIGHTNESS DATA

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Imager for Mars Pathfinder (IMP) sequence S0283 obtained data of sky brightness as a function of the scattering angle, wavelengths and Sol. This data set is fitted with a model calculations to extract the size distribution of the aerosols suspended in the atmosphere. The derived effective radius of the particles is about 1m or less. Farther work is continuing to constrain the complete set of the optical properties of the aerosols. Comparison of models with the spectral data from calibration targets appears to be especially promising in constraining the near IR values of the imaginary index of refraction. The derived properties of aerosols are compared to those derived from Viking Landers cameras and Phobos KRFM spectrometer data.

LATEST RESULTS FROM THE MARS PATHFINDER: ATMOSPHERIC STRUCTURE INVESTIGATION

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The Mars Pathfinder Atmospheric Structure Investigation (ASI) obtained information on Martian atmospheric structure from three science accelerometers, which measured the deceleration of the probe at all levels in the atmosphere, and a pressure sensor, which obtained pressure measurements in the lower atmosphere starting at about 7.4 km altitude. The Pathfinder entry profile represents the first in situ measurement of Martian atmospheric structure since the Viking landings in 1976 and the first opportunity to study Mars' nighttime atmospheric structure.

The temperature profile reveals a middle atmosphere (65 km to 125 km altitude) which is on average 20-25 K colder than the Viking 1 values. The minimum temperature of the profile at 80 km altitude is well below the CO_2 condensation temperature, suggesting the possible formation of nighttime CO_2 clouds in the middle atmosphere. In the lower atmosphere temperatures are somewhat warmer than or close to the Viking 1 values, contradicting groundbased microwave observations suggesting a much cooler atmosphere at these altitudes. We will report on the latest results and interpretations of the atmospheric structure found by Mars Pathfinder.

PS13

Pathfinder landing site coordinates: The perspective from the inertial and the global cartographic system.

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Tiepoint measurements, sunrise/sunset images, and photogrammetric adjustment techniques were used to obtain precise pointing data with respect to North for a set of 33 IMP horizon images. We measured azimuth angles for 5 horizon features, which can be reliably identified in Viking Orbiter data, and determined the Pathfinder location in terms of line/sample coordinates in Viking images by least-squares methods. To provide global cartographic context of the landing site, we recomputed inertial coordinates for 3739 selected, globally distributed, ground control points ("landmarks") seen in 1140 Viking Orbiter images using a global bundle block adjustment. The inertial coordinates of the Pathfinder and Viking Lander 1, derived from lander tracking, were used as fixed "anchor points" in the analysis. This currently best network of control points defines the relationship between the inertial and the cartographic coordinate system of Mars, and may help in optical navigation and mapping tasks for future orbiter missions to this planet.

IMP Image Calibration

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The Imager for Mars Pathfinder (IMP) has returned high-quality image data from the surface of Mars. Data quality is in good agreement with expected performance based on laboratory calibration. Extensive laboratory calibration resulted in a pixel-to-pixel uncertainty of <2% (after flat fielding) and an uncertainty in absolute radiance of <10%. In addition, two radiometric targets (RTs) and numerous color targets (CTs) were calibrated by DLR to <4% uncertainty in absolute reflectance. Instrument and target performance were verified with several datasets obtained during cruise and on Mars. Dark frames obtained during the mission agree with laboratory measurements, and flat fielding of sky frames indicates successful removal of pattern noise. Relative responsivity was verified by measuring the sky above the horizon in the three stereo filters, producing agreement of typically <1% between the eyes. Radiance measured relative to the RTs for the same dataset show agreement in stereo filters to <3%. CT radiances measured relative to the RT radiances are also in good agreement to laboratory results. Additional scene-dependent uncertainty is induced by lossy image compression that was applied to several datasets. In general, the performance of the instrument and calibration targets appears to be nominal.

THE IMAGER FOR MARS PATHFINDER EXPERIMENT (IMP)

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For 85 sols Mars Pathfinder sent back pictures of the surface of Mars that have been analyzed to produce a comprehensive visualization of the Ares Vallis landing site. From the nearly 17,000 images, a contour map of the surface has been generated and overlain with spectral information and rock distributions. These form the database that can be further studied by scientists throughout the world. In addition to information about the surface, a complete description of the atmospheric haze and its variation over the course of the mission has been developed. Extensive cross checks of the IMP give us confidence that the pre-flight calibration is still valid throughout the mission. The illumination of the the rocks and soil by the colored sky has also been studied and the spectral signatures for soil and rocks are now available. Magnets on the lander returned information concerning the strongly magnetic windborn dust and windsocks on the ASI/Met mast showed some evidence of wind gusts.

THE CHEMICAL COMPOSITION OF MARTIAN SOIL AND ROCKS AT THE PATHFINDER LANDING SITE: CURRENT RESULTS FROM APX MEASUREMENTS.

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After the successful landing of Mars-Pathfinder on July 4, 1996, chemical composition measurements have been performed on six soil and five rock samples by the Alpha-Proton-Xray Spectrometer attached to the Sojourner microrover. Preliminary results, based on the evaluation of Xray data only, have been published earlier. Following a careful recalibration with particular emphasis on the correction for contributions to the alpha spectra by the Martian atmosphere, data from all three modes (Alpha, Proton and Xray) have now been evaluated and the results are presented: The general picture does not radically change. However, directly measured data on oxygen and upper limits for carbon are now available and the accuracy of the results for other elements could be been moderately improved. In particular, data on oxygen permit to define bounds for the oxidation state of iron and the chemical form of sulfur.

EARLY RESULTS FROM THE MARS ORBITER LASER ALTIMETER EXPERIMENT: AN OVERVIEW

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In the Fall of '97 the Mars Orbiter Laser Altimeter (MOLA) on the Mars Global Surveyor (MGS) Mission acquired data over the northern hemisphere of Mars between latitudes 80N and 10S. A total of 18 orbital tracks equally spaced in longitude were obtained. The altimeter performed flawlessly with a precision of ~40 cm; the radial orbit accuracy is a few tens of meters. The topography of Mars' northern hemisphere shows significant flatness over thousands of kilometers with gentle slopes and a roughness that increases near the dichotomy boundary. Data over the layered polar terrain show significant smoothness compared to the surrounding area with a corresponding increase in brightness at 1.06mm. Many craters were observed with distinct central peaks and extensive ejecta blankets and appeared to be deeper than expected. Channels associated with Tharsis and other volcanic structures were found to be deeper than expected and showed little evidence of erosion. Volcanic flows have been identified throughout the hemisphere. The altimeter also provided estimates of atmospheric opacity and possible cloud heights.

REFLECTION FUNCTIONS OF MARTIAN SOILS NEAR THE CARL-SAGAN-MEMORIAL-STATION

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Optical investigations by the Imager for Mars Pathfinder (IMP) of soils near the landing site show distinctive regions with a wide range of spectrophotometric properties. APX-spectrometer measurements, however, have shown, that all sampled soils have similar composition. The apparent colour and shade variations observed by IMP could be due to variations of surface grain sizes or their state of compactness. Several targets, images of which are available at different illumination conditions and at different wavelengths were chosen for the present study. Spectrophotometric properties of these targets are derived by fitting Hapke's bi-directional reflectance function. The illumination by the diffuse Martian sky is taken into account.

The Mars Pathfinder Super Pan: USGS Analysis and Processing

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In the third week after landing, the Imager for Mars Pathfinder began an intensive photographic survey of the landing site. More than 2000 images (about 90%) of this Super Pan were taken over an 8-week period. At each camera position, 15 frames were collected: 6 for color stereo (440, 670, 965 nm) and 9 for spectrophotometry (left 800, 860, 900, 930, 1000 nm; right 480, 530, 600, 750 nm). The red and blue stereo pairs were losslessly compressed (1.3:1) and the remaining frames were compressed 2:1. Interframe overlap was increased over earlier mosaics to aid automated processing. After radiometric correction, digital terrain models (DTMs) are derived for each 15-frame set using a digital photogrammetric workstation, and these are used to perform a 3D rotation of each frame onto the right-red base image. A 3D control net is derived by identification of tie-points between frames, orientations of all frames are adjusted relative to one another, and the frames and their local DTMs are trnsformed to global coordinates to make mosaicked products. Examples of these stages show the precision and quality of the products and their use in 3D analyses of rocks, soils, and drifts at the Ares Vallis site.

THE SULFUR CONTENT OF THE MARTIAN CORE REVISITED: CONCLUSIONS FROM MARS PATHFINDER TRACKING

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The Martian interior is generally believed to consist of an Fe-FeS core of about half of the planetary radius, an FeO-rich silicate mantle subdivided into a lower spinel layer and an upper olivine layer, and a less dense basaltic crust. Due to the lack of seismological observations, however, core size and crust thickness estimates are only weakly constrained by the oblateness of the gravity field and by the chemical composition of the silicate phase as derived from possible Martian meteorites. The accurate determination of Mars' spin-axis precession period by radio tracking observations of the Mars Pathfinder lander therefore provides the most reliable constraint on internal mass distribution. The recently inferred polar moment of inertia factor closely matches the maximum possible value $C/MR^2 = 0.365$ formerly based on the assumption of Tharsis-dominated nonhydrostatic contributions to the planet's gravity potential. A further constraint on interior structure models is imposed by the geochemical requirement of a chondritic bulk composition of Mars. This suggests a core composition of roughly 40% Fe and 60% FeS by mass corresponding to a sulfur content of about 20 wt.% and a significant reduction of melting temperature in the core. While mantle temperatures are found to be sufficiently high to prevent the core alloy from inner core solidification, pressures close to 20 GPa at the base of the mantle appear to be insufficient for the spinel to perovskite transition to occur.

MEASUREMENTS OF THE ATMOSPHERIC WATER VAPOUR ON MARS BY THE IMAGER FOR MARS PATHFINDER

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The Imager for Mars Pathfinder (IMP) observed the Sun in the 0.94 micron H2O band and in the continuum around it. The observations were carried out at the sunrise and sunset to obtain great air masses in the atmosphere. The measured water vapour absorption was about 1.5% that corresponds to H2O column density of 6(+/-)4 precipitable microns. It was found that the IMP observations are hardly consistent with the usual assumption of water being uniformly mixed in the atmosphere. The observed abrupt increase in absorption with decreasing Sun elevation implies that most of the atmospheric water is confined in a thin (1-3 km) layer near the surface. The water vapor mixing ratio in the layer is 600(+/-)400 ppm.

THE MARTIAN SURFACE BOUNDARY LAYER: LATEST RESULTS FROM MARS PATHFINDER

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The Mars Pathfinder Atmospheric Structure Instrument/Meteorological package (ASI/MET) is the most capable weather monitoring system ever sent to the surface of another planet. During the surface operations phase of the mission, the ASI/MET instrument, equipped with a directional wind sensor, three thermocouples at 0.25, 0.5, and 1.0 meter above the surface, and a pressure sensor has returned more than 6.5 million individual weather measurements from the Carl Sagan Memorial Station. One of the prime objectives of the ASI/MET package is to characterize surface boundary layer parameters, particularly the heat and momentum fluxes, scaling temperature and friction velocity, and estimate surface roughness. Other important boundary layer parameters, such as Richardson Number, Obukhov length, analysis of turbulence characteristics of wind and temperature, and atmospheric stability class can also be determined from these measurements. The latest results from this investigation will be presented.

MONTE CARLO MODELING OF THE DIFFUSE FLUX NEAR ROCKS

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Rocks around the Pathfinder spacecraft , imaged by the IMP camera , e. g. Yogi, show color variations that change with the time of day. This is interpreted as being caused by a high ratio of diffuse to direct flux of the illuminating light. The diffuse flux is reddened with respect to a solar spectrum. The direct flux on an object depends upon the orientation of the surface with respect to a solar spectrum. The direct flux on an object depends upon the orientation of the surface with respect to the sun. Thus, the radiation field at a point on the surface depends upon the orientation of the surface and the surrounding topography. To understand and assess this effect we use a 3D Monte Carlo radiative transfer code which incorporates a realistic model of the surface elements. Beside the ray-tracing of photon histories, treatment of surface reflection as well as scattering by atmospheric components is included. Our model calculations reproduce the observed trends in the diffuse to direct flux ratio. The real reflectance spectra of the targets will be constructed from the IMP data utilizing these calculations.

MARS' ROTATION AND PRECESSION FROM PATHFINDER AND VIKING RADIO TRACKING DATA

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Doppler and range tracking to both the Mars Pathfinder lander and Viking landers have been used to determine the processional motion of Mars spin axis and seasonal variations in Mars axial rotation. These orientation parameters are particularly sensitive to the Doppler data. Viking S-band Doppler sensitivity is about 1mm/sec while X-band Pathfinder data noise level is 10 times smaller. Mars precession is caused by a solar gravitational torque acting on the oblate figure of Mars and also depends on Mars moment of inertia. The estimated precession rate of Mars' equator relative to its orbit from this combined data set is -7576 ± 35 mas/ yr (milli-arc-seconds). The corresponding moment estimate is 0.3662 ± 0.0017 and is consistent with previous theoretical estimates which argued that Tharsus volcano was the primary contributor to its nonhydrostatic figure. This estimate is also consistent with interior models which have a mantle enriched with iron compared to Earth. We have also solved for periodic terms in rotation with periods ranging from 1 to 1/4 Martian year. However, only the annual and semiannual terms are deemed significant. The annual term agrees quite well with a simple model for ice cap history where air pressure changes are used as a proxy for differential mass changes. These and additional solution parameters such as lander locations shall be discussed.

INTERNAL STRUCTURE OF MARS AND Fe/Si RATIO

V.N.Zharkov, T.V.Gudkova (Institute of Earth Physics, B.Gruzinskaya, 10, 123810 Moscow, Russia)

We have constructed a set of Martian models,which consist of the crust, the mantle and the core. The starting-point of our paper is Waenke-Dreibus cosmochemical model. The construction of the models of the crust and the core is considered as a separate problem.
The mantle models had been constructed on the basis of the experimental data for Martian composition and then they were joined our models of the crust and the core. Mineralogical models of Martian crust were developed using the method of numerical simulation. The mineral composition of the consolidated crust varies with the depth because of the transition of gabbro-eclogite type. The data on the structure of the outer layer of the Moon were taken into account in modeling the outer (10 km), porous layer of the planet. Computations were performed for the compositions of basaltic SNC meteorites and for four variants of the temperature distribution in the crust. The experimental data on the system Fe-S-H-C are summarized, cosmogonical arguments in favor of the presence of hydrogen and carbon in the Martian core are given and the influence of hydrogen and carbon on the physical parameters of the core is estimated. The core radius depends on many factors: it is very sensitive to the density at the top of the mantle, the temperature distribution, the density of the core and the thickness of the crust.

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